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Electric Tramway Enterprise.

THE TRAMWAYS EXHIBITION.

JULY, 1902, may possibly prove an eventful date in the history of the progress of electric traction in this country. If so, it will not be by reason of the granting of any new legislative charter, but rather on account of the opportunities afforded for the growth of that *esprit de corps* amongst all engaged in the industry which is a necessary preliminary to the united action so essential in these days of vote-seeking political party Governments.

The month has been rendered eventful by reason of the second International Tramways Exhibition held during the first half at the Agricultural Hall, Islington, and opened by the Right Hon. Gerald Balfour, M.P., the President of the Board of Trade.

The Exhibition was arranged by *The Tramway and Railway World Publishing Company*, and great credit is due to them for the energy and ability with which the scheme was conceived and carried out. It served to arouse a great deal of public interest in tramway progress, and was a means of educating those who visited it to a sense of appreciation of what an electric tramway really should be. Its great value has been rather of an indirect than direct character. It has served as the rallying point for tramway experts from all parts of the world. Not only have modern appliances been examined and new methods of working inquired into, but meetings have been held, opportunities for social intercourse given and taken advantage of, and each has returned to his own sphere of work knowing more of the experiences of his fellow-workers and feeling in a clearer measure that he is not a solitary individual fighting a battle of despair, but a unit in a well-organised and powerful industry ready and able to bring pressure to bear upon the "powers that be" in such a manner that the disabilities the business labours under will in due time be removed.

The formation of one Tramway Association during the period of the Exhibition, and the practical reorganisation of another, are evidences that the interest of the present will bear fruit in the results of the future, while more immediate advantages may be hoped for from the official visits of the many tramway committees and such bodies as the Incorporated Municipal Electrical Association, composed largely of men who are daily advising as to the placing of large orders for traction apparatus.

This feeling of community of interests has been immensely strengthened by the holding at the exhibition of the biennial congress of the Union Internationale Permanente de Tramways, the most influential tramway association on the Continent. The opportunities for intercourse, social as well as professional, with so many of the leading tramway experts in Europe have not been wasted, and should do much to abolish that feeling of insularity which limits not only our sympathies, but also our range of knowledge and fields of usefulness.

THE EXHIBITS.

We deal elsewhere with the exhibits themselves. Compared with those shown at the last Exhibition of the kind, held two years ago, a great advance, both in numbers and in quality, could be noted. British brains are developing the design and manufacture of traction appliances along British lines. The fact that an article has proved a success in other countries is no longer a passport to approval here, and on many of the stands we were pleased to note evidences of a prosperity which proved they were more than able to hold their own against foreign trade competitors. It was also interesting to note that since

the last exhibition some of our most important firms, whose names have hitherto been closely associated with America, have gone far towards themselves being in a position to manufacture on British soil. The British Westinghouse Company were glad to give the fullest information as to their magnificent new works at Trafford Park, near Manchester, while the British Thomson-Houston Co. were not slow to remind you that their headquarters were not Schenectady but Rugby. The Brush Company were in evidence with tramway plant of all descriptions, specially emphasising the fact that they had been successful in producing a British-made truck able to meet in strict competition the still popular foreign article. Messrs. Dick, Kerr & Co. were able to give magnificent testimony to the excellence of their car and motor equipment work, and all visitors to the exhibition enjoyed a look at the biograph representations of the interior of their Preston works. It was impossible for anyone to examine, in however cursory a manner, the 200 distinct exhibits shown on the various stands without feeling how rapidly the manufacture of electric tramway appliances was taking its place as one of the important industries of the country.

VISIT OF PRESIDENT OF BOARD OF TRADE.

The President of the Board of Trade took advantage of his visit to open the Exhibition to extend a welcome to the members of the Union Internationale then assembled for their first meeting. It was generally held to be a gracious act thus to afford an indication of Government interest in the visit of the Union. At a later period a royal message of encouragement completed the friendly relationship with British official life thus happily commenced.

Mr. Balfour did not in his speech offer much encouragement to those who anticipated great things. He was ready to acknowledge the backward condition of tramway enterprise in this as compared with other countries, but he bade his hearers look in other directions than towards the Board of Trade for the cause. He instanced their treatment of the Portrush electric tramway with its exposed third rail conductor as an example of the tolerant manner in which the Board of Trade fostered new industries, and in congratulating the meeting on its international character, expressed his belief that we were now determined to make up our lost leeway.

It was evident that, though apparently unsympathetic in manner, Mr. Balfour is gradually being brought to recognise the importance of the tramway industry, and the need there is for the removal of those unfair conditions which at present prevent it from taking its part in the solution of some of the pressing social problems of the day.

UNION INTERNATIONALE PERMANENTE DE TRAMWAYS.

The aim of this Union, founded in 1886, is to help forward the tramway industry by every means in its power, irrespective of nationality. It has hitherto been little known in this country, though those who attended its meetings in Paris two years ago formed a very high opinion of the value of its work. The meeting in London was arranged on the invitation of the Tramways and Light Railways Association, and it has in every way proved a success. The Union has been benefited by the wider publicity given to its proceedings, while the papers and discussions have been of service to many who otherwise would not have known of them.

It is interesting to notice that the *Times* considered the proceedings of the Congress of such importance that it gave an account of the various meetings. May we hope that this is an evidence of a determination on the part of our educated Press to devote, in future, more attention to subjects of real social and industrial importance?

The Union is held in very high repute on the Continent. Its Committee of Management include the names of the principal officials of the leading tramway companies, and such Governments as France, Germany, Austria, Italy, Hungary, Belgium and Russia officially appointed delegates to represent them at the recent meetings. It had the good fortune to

have as its President M. Léon Janssen, the talented managing director of the Brussels Tramway company. The meetings of the Union extended over four days, and it says much for the devotion of its members, that, amid the many attractions of the Metropolis, the attendances were so well sustained throughout.

In his presidential address, M. Janssen referred with pride to the prestige the Union enjoyed, and went on to point out the absolute importance of the collection of correct information respecting the different phases of the business. Fortunately, it was possible for this information to be given without in any sense injuring the prosperity of any individual undertaking. The Union had recently established, at their headquarters in Brussels, a separate department to deal with statistics of this character. All particulars thus obtained would be at the disposal of every member of the Union, and he trusted that each would not only be ready to make use of, but also to add to the general fund of knowledge. It was very necessary that the data should be collected on a uniform basis, so that useful and accurate comparisons could be made. What that basis should be it was for the Congress to decide.

For portions of the sittings of the first three days it had been arranged that prominent Englishmen should occupy the chair, and in this connection Sir Charles Rivers, G.C.M.G., President of the Tramways and Light Railways Association, Colonel Boughey, C.S.I., one of His Majesty's Light Railway Commissioners, and Mr. John Young, the Manager of the Glasgow Tramway undertaking, each in his own way expressed interest in the work the Union was carrying on.

THE PAPERS.

The papers which were read and discussed covered practically every phase of tramway and light railway work. As, by reason of its international character, it was necessary to conduct the Congress in three languages (French, German, and English), the time available for debate was considerably curtailed.

The subjects naturally divide themselves into two groups, managerial and technical. In the first we may class the papers dealing with the issue of Transfer Tickets, the terms upon which Concessions should be granted, the consideration of Legal Restrictions, the proposed adoption of a Uniform System of keeping Accounts, and the suggestion that Tramway Companies should organise a parcels collection and delivery business, while in the latter we may include those dealing with Brakes, Systems of Heating Cars, Questions of Gauge, Types of Plant, Conduit and Surface-Contact Systems, the Rating of the Power of Motor and Tube Railways.

The originality of the papers was to a large extent destroyed by the system upon which they had been prepared, but what, according to our British ideas, they lost in brilliance they probably gained in usefulness. It is the custom of the Union, when deciding upon the consideration of a subject, to arrange a list of questions, which are sent to each of the Companies associated in its membership. The replies received are then forwarded to one of the members, who prepares a paper summarising the documents sent him, and adding, if he thinks fit, his own ideas and opinions. The result is the collection, often in a rather uninteresting form, of a large amount of information giving at first hand the fruits of actual experience.

TECHNICAL SUBJECTS DEALT WITH.

It is outside our province to deal with those papers treating of managerial subjects, but amongst those of a technical character there were some which merit more than passing attention.

In this category we may include that read by Professor Rasch of the Polytechnic School at Aix-la-Chapelle, upon "The Correct Basis for Rating the Power of a Traction Motor." The author commenced by pointing out differences in practice in the way of testing motors. The attempts made by the German Association of Electrical Engineers to standardise the conditions of testing by the issue of a set of regulations were then commended, and a new method of rating motors in which the important element of

torque was taken into account was explained. He concluded by giving in tabular form a suggested list of questions to be answered by all firms quoting for traction motors which would permit of a fair comparison of different offers being made. After a full discussion the Congress decided to await the report of the British Standardisation Committee before taking any definite action.

M. Ch. Thouet, the manager of the General Contract Company of Liége, read an interesting paper showing the tendency of present-day power-house design on the Continent, and giving valuable information as to the cost of working stations of various sizes, using different types of prime movers.

The paper prepared by M. Ziffer, the president of the Board of Directors of the Bukovina Light Railways, upon conduit and surface-contact systems of traction is a very mine of information. It contains much that has hitherto been unpublished about the various systems on trial in different places. The writer concludes by expressing his opinion that at the present time an open conduit is more reliable than a surface-contact system.

A long and animated discussion took place upon M. Builet's paper dealing with "Narrow *versus* Ordinary Gauges for Light Railways" The writer, as general manager of the Société Nationale des Chemins de Fer Picinaux de Belgique, which has in operation 96 light railway lines of a total length of nearly 1,250 miles, naturally spoke with authority. Unless there were special reasons which rendered the use of standard gauge desirable, he was decidedly of opinion that it was best to adopt a narrow gauge of, say, 1 mètre. Such lines were practically half the cost to build, cheaper to operate, and they enabled a line to a large extent to seek its own traffic The cost of transhipment at junctions with main lines was small, and the inconvenience to passengers was less than many people imagined.

Several speakers thought there were many places in this country where narrow-gauge lines might with advantage be constructed. Such places were at present without railway accommodation because it would not pay to build a standard-gauge line. The utility of the narrow-gauge military lines in North India, where the gauge was only 2 ft. 6 ins., was mentioned, as also the fact that all the stores used in the late Boer War had been carried over the 3 ft. 6 ins. gauge lines in use in South Africa.

The paper upon Brakes, read by M. Poetz, the Chief Engineer to the Hamburg Tramway Company, advocated the use of electric as opposed to pneumatic brakes. M. Koehler, the Managing Director of the Berlin Tramways Company, differed from the writer, his experience being that the pneumatic brake was the more reliable. Several speakers considered that the electric brakes tried and discarded by M. Koehler were of old pattern, and that the latest types of electric brakes were reasonable in cost and reliable in action.

Mr. McMahon, the Chief Engineer to the City and South London Railway, read an interesting paper upon the various Tube Railways in London. The results of working, so far as could be ascertained, were given, in addition to some useful figures showing the effects of increased acceleration upon the station capacity of the line. A discussion then took place upon the demerits of accumulators when employed for the storage of energy on the cars. M. Röhl, the Managing Director of the Hamburg Tramways Company, who introduced the subject, referred to the disastrous failure they had proved at Hanover, and the fact that even at Hagen, the centre of the accumulator manufacturing industry, they had been tried and abandoned. Other speakers voiced the same story. At Dunkirk, Paris, Berlin, in various Austrian towns, their use had meant the same story of failure and loss. No one had a word to say in their favour, and when someone proposed that the Congress should express an opinion that their use on cars was undesirable in the interests of the industry, the difficulty was to make the resolution expressive enough. The Congress was closed by a short address from M. Janssen, thanking all who had helped to make the meetings such a success.

ASSOCIATION OF MUNICIPAL TRAMWAY MANAGERS.

This Association, formed during the period the Exhibition was open and within its precincts, bids fair to have a successful career. It is the outcome of a desire on the part of the rapidly increasing number of responsible officials holding positions in municipal tramway undertakings to associate together, and it has already attracted to its membership practically all the municipal tramway managers in the country. Mr. John Young, the well-known chief of the Glasgow tramway undertaking, is the first President, and Mr. John H. Rider, the tramways engineer to the London County Council, the Vice-President. It was noted at the dinner given by the Exhibition Committee to the members of the new Association that, though they were few in number, they were potent in influence, for they represented no less than £20,000,000 of public money invested in tramway undertakings.

DEPUTATION TO BOARD OF TRADE.

Advantage was taken of the presence of so many responsible tramway officials and members of Tramway Committees in London to arrange a deputation to wait upon the Permanent Secretary of the Board of Trade and discuss several regulations which are found to be prejudicial to the successful working of large traction systems. The deputation represented all the important provincial municipalities who own and work tramways, and it may reasonably be hoped that their efforts will result in the modification of some of the restrictions which press heavily upon all actually responsible for the running of lines.

The reception of the deputation by Sir Francis Hopwood, who was accompanied by Colonel Yorke, was all that could be desired, and certainly left the impression that individually the officials of the Board of Trade recognised the difficulty of complying with all the requirements they felt bound to impose.

The first question to be discussed was that of maximum speed. At present the usual maximum allowed is ten miles per hour, and in the case of a line running through a large town from one suburban district to another, the usual average speed was about five miles. This is felt by all tramway men to be a mere travesty of "rapid transit," and they unanimously asked for a permissible maximum speed of not less than sixteen miles per hour. Many representatives thought that twenty miles in suburban districts would not be too much, but Mr. Paton, of Glasgow, the spokesman of the deputation, assured Sir Francis Hopwood that none of them considered sixteen miles too fast for country and suburban districts. Were this permitted it would allow the average speed per trip to be increased to seven or eight miles per hour. It was of great importance to passengers that they could get from one point to another as quickly as possible, and in their opinion this was the special advantage of tramways as a means of urban locomotion.

Another point they wished to discuss was the provision that speed indicators should be fixed upon all cars. It was true that the Board had not yet definitely insisted upon this being done, but there were many objections to it, and, besides, they did not yet know of a suitable and reliable instrument. They also wished for modifications in the stipulations relating to trailer cars, the carrying of red lights, and the limiting of the amount of energy to be carried by any feeder to 300 kilo-watts.

Sir Francis Hopwood pointed out that in several cases the Board of Trade had already sanctioned higher speeds than ten miles an hour on portions of routes, they were, however, in many cases, bound by Acts of Parliament, in which the speed was limited to certain figures. He was in favour of recommending the Board to omit in their regulations the clause referring to maximum speed, leaving each case to be decided by the Inspector examining the line. He impressed upon the deputation the need of minimising, as far as possible, the possibility of accidents, and, as for the speed indicators, thought the best time to fight that regulation would be when the Board actually insisted upon its observance. The other points raised would be brought under the notice of the Home Office and other officials principally concerned.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

Last, but by no means least, we may refer to the meetings of the Incorporated Municipal Electrical Association, which were also arranged to be held in London during the same busy week. Founded seven years ago, this Association has fought its way to the front, and at the present time it enjoys the confidence and membership of the large majority of borough electrical engineers and municipal electric lighting committees. The Association, in our opinion wisely, limited the number of papers to be read and discussed to six, two at each meeting, and included in their programme an official visit to the Exhibition.

On the first day of their convention, after the Presidential address by Mr. Rider, the Association listened to papers upon "Double-Current Generators and their Application," by Mr. Ruthven-Murray, who is employing them at Willesden; and "High-Tension Continuous-Current Systems," by Mr. Barnard, of Hull. The third day was devoted to a consideration of "The Relative Advantages of Two and Three-Wire Distribution," introduced in a paper read by Mr. J. F. C. Snell; and "Notes *re* Earthing," by Mr. H. Faraday Proctor, of Bristol. All these subjects, important in themselves, are of only limited interest, and it is rather to the papers read at the second day's meeting that we wish to draw special attention.

The papers were entitled "Steam Turbines," read by Mr. S. E. Fedden, and "The Correct Type of Engine for Large Generating Stations," read by Mr. A. A. Day. The discussion proved not only interesting, but valuable, a number of opinions being given by leading men upon the possibility of the steam turbine in the near future superseding the older designs of reciprocating engine now in use. We need hardly say that fresh from the inspection of some of the largest power stations in the country, where the steam turbine is working alongside more orthodox types, the subject was particularly attractive. Mr. Fedden in his paper pointed out the advantages which he had found by experience that steam turbines possessed, and justified his selection of them for use in the new station now in course of construction at Sheffield. Mr. Day, omitting all reference to turbines, spoke of the tendency towards larger and larger units, and showed that wherever the question of ground space was not of vital importance the slow-speed horizontal type of engine was, in his opinion, best. In these latter days, when the generating stations were, for the most part located outside the area of supply, the cost of ground became less, and in reality, as the size of unit became larger, the space occupied by the boilers became more and more the dominant factor. The slow-speed horizontal type of engine had many advantages, and for other classes of work had proved itself thoroughly reliable and successful.

Several of the speakers who followed agreed with Mr. Fedden as to the future field of usefulness open to the steam turbine. Those who had had practical experience with them expressed their satisfaction, but pointed out that the electrical designs of the dynamos and alternators used in conjunction with them were capable of great improvement. Indeed, so far as dynamos were concerned, they were not by any means satisfactory. The difficulties regarding commutation in large dynamos at high speeds were very great, and up to the present they had not been surmounted. The vertical type of engine in both what we may term its low and high-speed types met with several advocates; and, on the other hand, a preference was expressed for gas engines, some enthusiasts looking forward to the time when the still undesigned gas turbine will have superseded the temporary makeshifts of prime movers in favour to-day.

Although few went so far as Mr. Day in his advocacy of the slow-speed horizontal-type, many thought that in the immediate future slow-speeds would be largely adopted for the five and ten-thousand horse-power sets which it will become the usual practice to instal.

The discussion in reality only proved how far we are from finality in our present engineering methods and reminded us of the vast field of research which is still open to the diligent student.

Original Signed Articles

Floating Graving Docks.

By S. F. STAPLES.

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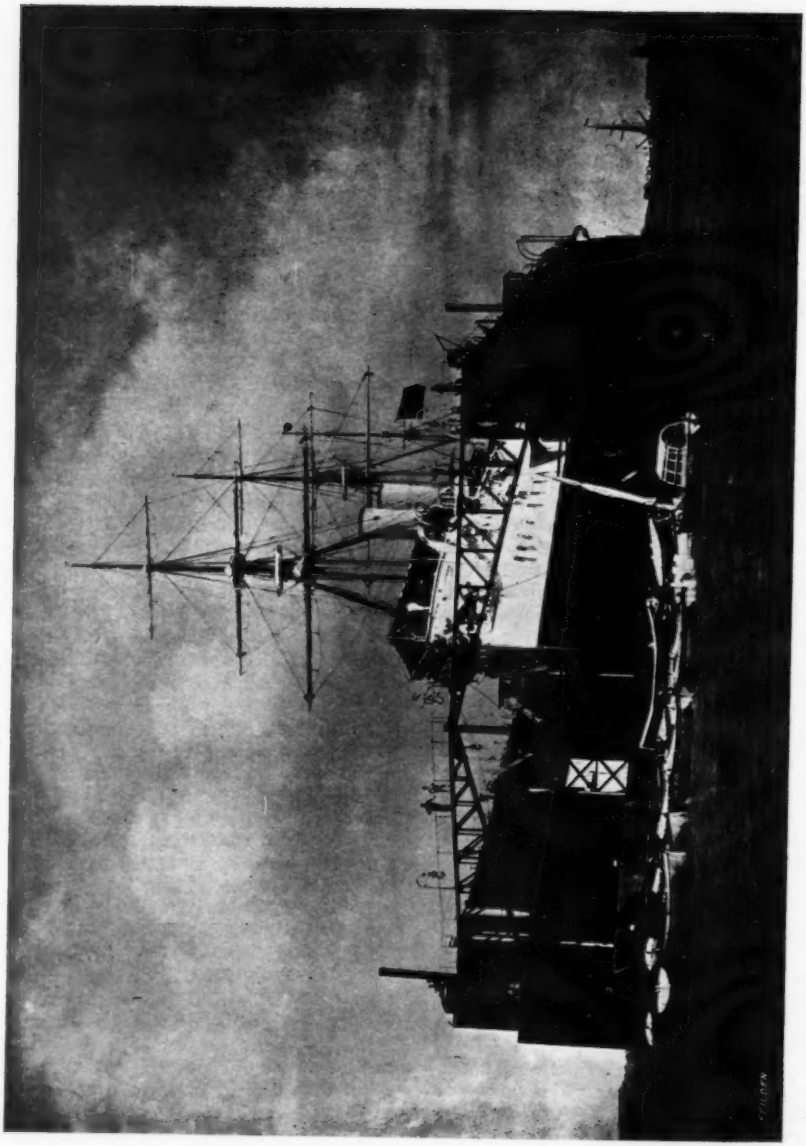
SOME time ago it was found imperative to supply at the port of Havana dry dock accommodation, and that as speedily as possible. As both time and money were important factors in the case, it was impossible to have a stone dock, owing to the time such a dock would take to construct and the unsuitability of the site; so, accordingly, tenders were called for for the design and construction of a steel floating dock.

The problem presented was, briefly, as follows. The dock was to be capable of lifting any short but heavy battleship in the Spanish navy whose displacement did not exceed 10,000 tons, and, at the same time, to be able to lift any of the long and comparatively light cruisers or Trans-Atlantic mail steamers. The dock was also to be capable of allowing the inspection and repair of any part of its underwater portions without having recourse to any extraneous appliances. The dock, moreover, was to be delivered ready for work in the harbour of Havana within eleven months from the time of signing the contract for its construction. This latter condition carried with it, in effect, the condition that it should be able to stand a long sea-voyage.

The writer's firm (Clark & Standfield), who were the engineers to the scheme that was eventually adopted, attacked the problem on somewhat novel lines; and in this connection it may be of interest to follow out their line of reasoning, and incidentally to briefly examine some of the various forms of floating docks at that time existing, noting their separate advantages and disadvantages in connection with the problem we are now dealing with.

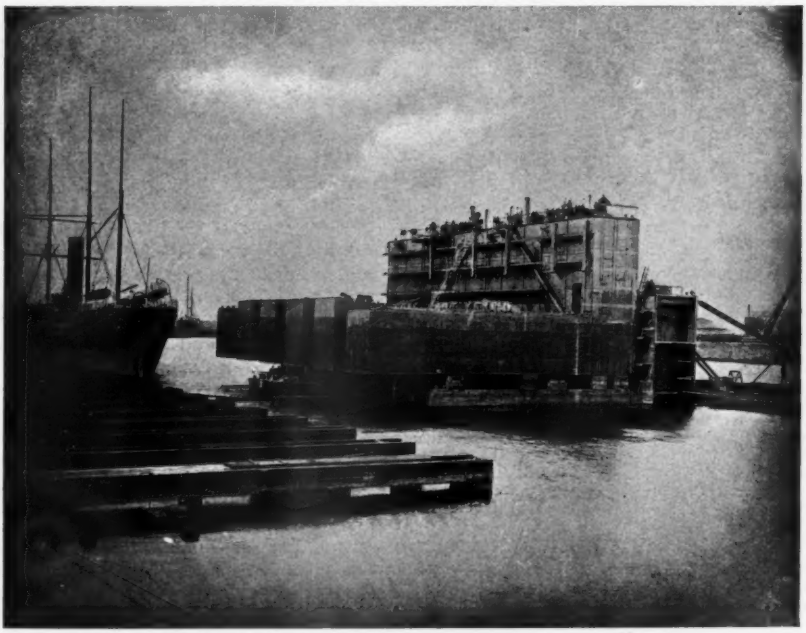
In very busy commercial ports, where quay space can be obtained for the necessary staging, a depositing dock is very economical, if the work to be done on the ships be chiefly repairs and not merely painting and scraping. This, as will be seen from the illustration, consists of a single-sided dock, at the back of which is a floating outrigger connected to the wall of the dock by means of pairs of hinged booms; and, as the outrigger always tends to float level, it acts as a means of steadying the dock during the operation of lifting or lowering the ship. The platform on which the ship rests when lifted is not continuous, but is divided up into fingers with spaces in between. Along the shore there is a series of stages of about the same width as the dock, and the spaces between the stages correspond to the fingers of the dock. It will be seen, therefore, that if the ship be raised by the dock above the level of the water and then be warped alongside the staging so as to bring the stages between the fingers of the dock, if the dock be lowered, the ship



"ALFONSO XII." ON THE HAVANA FLOATING DOCK.

will be left high and dry on the staging, and the dock may be taken away to lift another ship, which in turn can be deposited, and so on; the only limit being the extent of the staging. It will be seen that a dock of this kind can deal with a very large number of ships. Such a dock is somewhat expensive, as, owing to the form of its construction, it takes a larger amount of material for a given lifting power than many other types of docks. The pontoon or lifting part proper being discontinuous, it requires to be made proportionally deeper than would be the case if it were not divided into fingers; as, of course, the spaces between the fingers are completely lost as far as lifting power is concerned. This necessitates a greater depth of water for the dock to work in, which at times is a disadvantage. This dock also possesses little or no longitudinal strength, which, although of no importance in the case of merchant vessels, is of very great moment when battleships have to be lifted, owing to the great concentration of weights which occurs in these ships. A very short inspection of one of these docks shows that it is most unsuited for towing.

Briefly then, the depositing dock is best suited for busy ports where a large number of vessels have to be dealt with for repairs by one dock, where space for the staging is available, where water is fairly deep, and where the dock can be constructed on or near the spot.



DEPOSITING DOCK AT BARROW, SHOWING METHOD OF SELF-DOCKING.

The next type of dock which presents itself for examination is very similar to the last, but with the pontoon continuous instead of being cut up into fingers. This is called the outrigger dock. It will be seen at once that the depth of the pon-

toon of such a dock will be considerably less than that required by the former type owing to the spaces between the fingers being in this case utilised as lifting power. This is a very useful dock in ports where it has to lie afloat away from the quay wall, or in places where the bottom shelves very gradually, which would necessitate either a very large amount of excavation, or that the dock should lie a long way off the shore where the shops are situated. It is here, then, that the benefit of the outrigger is seen; as it may be utilised as a small repairing shop, and light punching, shearing and drilling machines placed upon it, these machines being worked by the same boilers which supply steam to the dock engines. This type of dock has more longitudinal strength than the former, and may be towed for short distances if very rough weather is not anticipated. It would be quite possible, although not economical, to construct an outrigger dock which would take the short, heavy ironclads and also cruisers or merchant vessels.

The next type of dock which we will examine is one of far wider application, namely, the off-shore. This is a single-sided dock which is attached to the shore by means of parallel booms, the shore ends of which are hung to upright columns. This is by far the best dock yet devised for merchant vessels, more particularly if, as is often the case, the dock is installed in a tidal river. Having only one side, ships can be warped on sideways to the dock, or they may be sheered in by the force of the tide itself. These docks are extremely rapid in their action, and are of very general application. They are usually placed directly in front of the repairing yard; from which they are approached by means of one or more broad gangways, so that no time is lost in getting men and materials on and off to the ship. This type of dock is considerably the cheapest in first cost, and is the most economical in working. Where there is a boiler to work the shops in the immediate vicinity of the dock, this may be utilised to drive the pumping plant of the dock.

Vessels are shored on this dock, as on other single-sided ones, by means of hinged bilge shores which are worked from the top deck of the side wall. There are also telescopic horizontal shores, which work through the wall and are also actuated from the top deck.

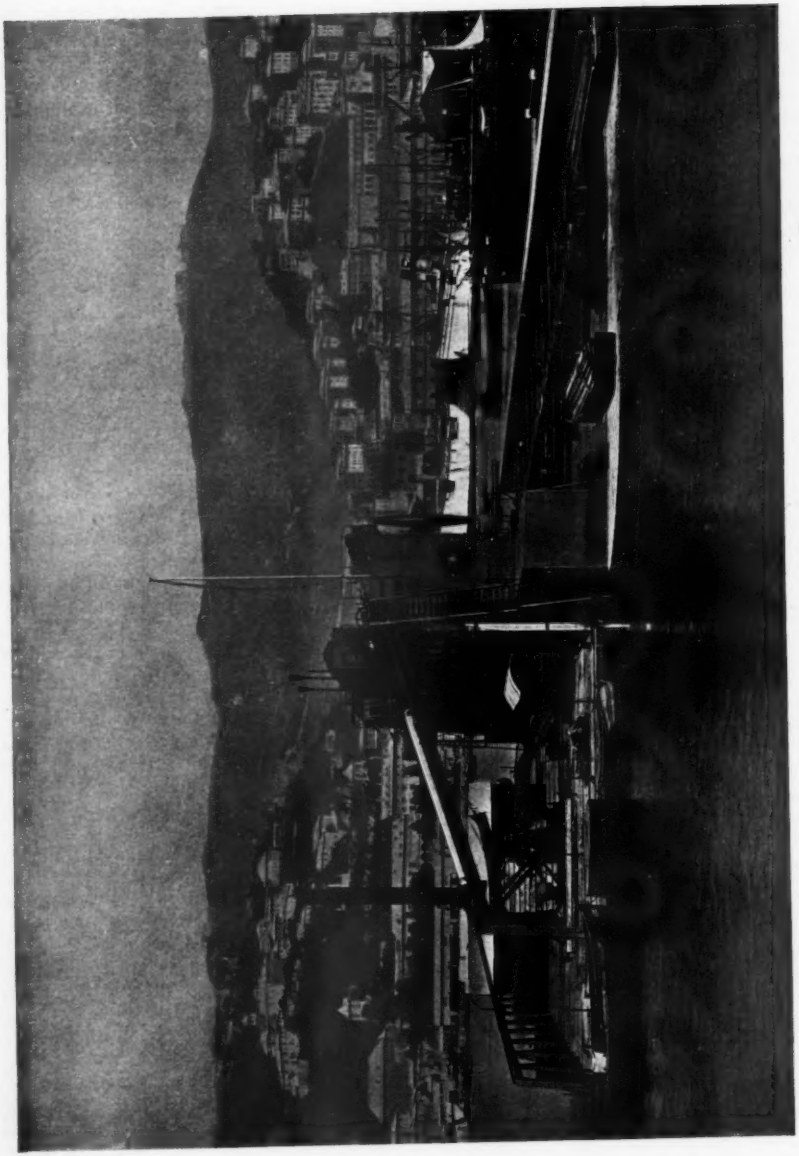
This type of dock can be made suitable for battleships, but it is not suited for ocean voyages. They have been towed from the London River to Cardiff and to Aberdeen, but it would be a difficult operation to tow one across the Atlantic.

All these forms of single-sided docks are made self-docking by being constructed in two lengths, which, when at work in the ordinary way, are connected together; but when requiring to be docked, one half is lifted by the other, in the same way as a ship is lifted.

This brings us to the end of the different types of single-sided docks, and the first thing which is apparent with double-sided docks is that they are evidently more suitable for towing than those with only one side.

The simplest and strongest form of double-sided dock would undoubtedly be one with the pontoon and walls in one single construction. This form, however, possesses the fatal defect of rendering it impossible to get at its underwater portions for the purposes of cleaning or repairs. It is true that some docks of this type have been constructed in Holland, and they are cleaned by means of an inspection chamber which can be floated underneath them, and the water pumped out so that the whole of the bottom of the dock can be successively got at. It is obvious that, in a closed chamber of this sort, it must be very difficult to get paint to dry properly or to work satisfactorily; and the opinions of owners of these docks are very diverse upon the subject. But for this defect this type would be the strongest and most economical of all.

If such a dock as this were supposed to be cut up into short lengths each of which was shorter than the distance between the walls of the dock, it will be seen that then any section can be disconnected from the rest and floated between the walls of the dock and lifted as if it were a ship, and



OUTRIGGER DOCK AT GENOA.

the dock thus be self-docking. This is the Sectional Dock which, constructed of timber, is largely used in the United States. It is obviously without any longitudinal strength and unsuited for towing. It has the advantage that, if the dock be a large one, it may be divided into two or more lengths, and each of these used separately, just so many sections being utilised as are required for the particular ship to be lifted.

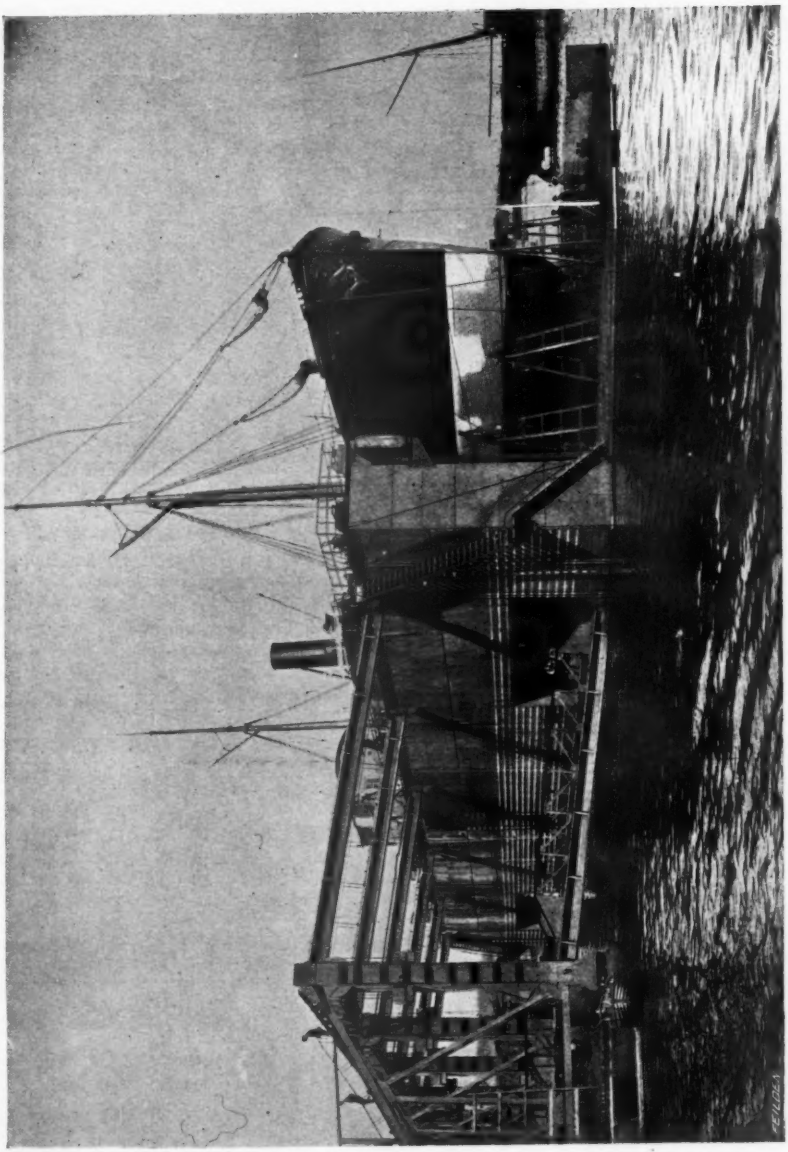
If now, in order to obtain longitudinal strength, we suppose the different sections of the walls rigidly attached to one another, but the pontoons being still separate from one another and detachable from the walls by means of a joint at the level of the deck, we still have a self-docking dock, as each pontoon can be floated out separately and docked as before; but the dock, as a whole, has a considerable amount of longitudinal strength owing to the walls being continuous. This is the ordinary form of self-docking double-sided dock, and has been often employed.

Another advantage of this system lies in the fact that these different sections of pontoon are of small size, and may be constructed in any convenient portion of a yard and launched separately; and, their weight being very little, nothing elaborate in the shape of launching-ways is required. When all the pontoons have been launched they may be connected together and the walls built *in situ* on top of them. Where a yard might not have sufficient depth for the construction of a large dock in one piece, it may easily be found practicable to build it in small pieces, as indicated above. This brings us to a further good point possessed by this type of dock, and that is, owing to the absence of neces-ity for elaborate launching-ways, such a dock is very suitable for construction at home and re-erection abroad where no facilities are to be found for launching a very large structure. The pontoons are, in fact, nothing more, in the way of weight or dimensions, than large barges; and in out-of-the-way parts of the world it is often found more advantageous to ship the dock in pieces and re-erect. This method of procedure has been adopted by the writer's firm in several cases of docks constructed for distant parts.

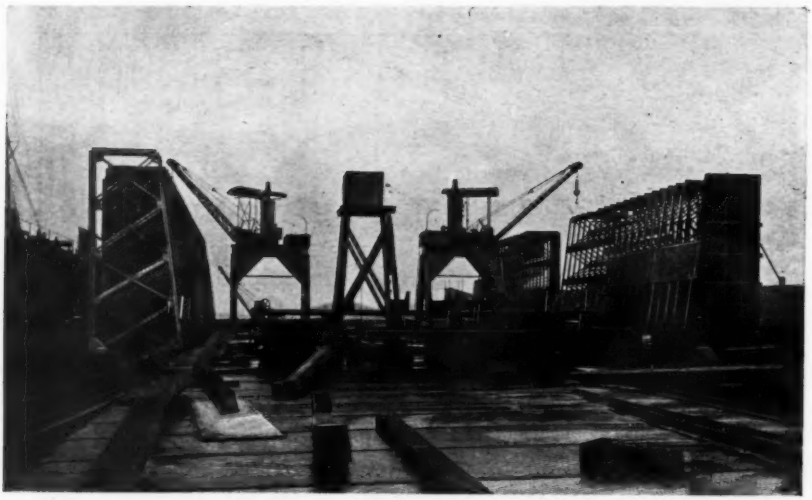
In a port where the ships to be dealt with are all very much of a size, this type of dock is very suitable, or if it is to be used for battleships only; but if the dock is to be made of sufficient length to take very long cruisers or liners, it will be found very weak longitudinally if it is to be used for short heavy battleships. This is, of course, presupposing that the scantlings are to be of anything like economical dimensions. This weakness will show itself in the buckling up of the ends of the dock, which will be thus called upon to exert all their lifting power without having the weight of the ship over them to counter-balance their displacement. It would, of course, be possible to give the whole dock a nett displacement per foot run, equal to the weight of a heavy battleship per foot, and then only use those compartments which come directly below the keel. This, however, would be found to give the dock an enormous amount of superfluous buoyancy, and her draught of water and weight of material used in her construction would be very much more than should be required. The side walls might be strengthened as girders so as to resist the strains which would be thrown upon them by the end pontoons not taking any weight, but this would again entail the use of a very large amount of material and add greatly to the cost.

The foregoing considerations led the writer's firm to evolve a new type, which they called the floating graving dock, so as to get over the difficulties which have been enumerated, and to give a form of dock which would be able to deal with any class of ship, and at the same time not entail the extravagant use of material in construction. The dock which was designed for Havana was the first of this type to be constructed, and its success was such that others have followed in its wake for different parts of the world.

The Havana dock is of the double-sided type; but one of the most important differences between it and any other dock which had preceded it, lay in the fact that, instead of the walls of the dock



OFF-SHORE DOCK AT FLENSBURG.



AMSTERDAM DOCK IN COURSE OF CONSTRUCTION, SHOWING JOINT OF WALL TO PONTOONS.

being constructed on top of the pontoons, they were carried down nearly as low as the bottom of the dock, and the pontoons come between them. By this means about 15 ft. of extra depth is added to the walls, and looking upon them as girders, it is easy to see the immense addition to their strength thereby gained, and that with practically no additional weight of material in the dock.

The extra stiffness thus obtained is not the only precaution that has been taken to ensure no straining of either the dock or the vessel, in the case of lifting a short, very heavy battleship. In this connection it is well to point out that for docking purposes the length of a ship, as given in "Brassey's Naval Annual" or similar publications, is by no means an indication of the length of the ship for docking purposes; that is to say, it gives no indication of the length of straight keel which, of course, is one of the most important factors to be known in estimating the strains which will be thrown upon a floating dock in lifting a ship. For instance, there is a vessel at the present time under construction for the Italian Navy, whose length of straight keel is only 41 per cent. of her total length: as given in "Brassey," the *Idzumo* has 58 per cent. of straight keel, and our own *Powerful* has just under 77 per cent. In order to eliminate the longitudinal strains in this dock as completely as possible, caissons have been fitted to each end of the dock, which drop into slots up the face of the altars. These are very light, floating structures, about 8 ft. high, and their application is briefly as follows. When the battleship has been placed in position over the blocks, water is pumped only from the portion of the dock under the ship. This has the effect of raising her out of the water to a considerable amount, but the displacement of that portion of the dock would not be sufficient to get her quite high and dry. When she has been lifted as much as possible, the caissons, which have previously been floated into place, will be found to have their tops above water. At this stage the total force employed in lifting the ship is brought to bear immediately under the weight to be lifted, and there is no tendency for the ends of the dock to curl up and so strain the ship. When the pontoons being pumped are found to be

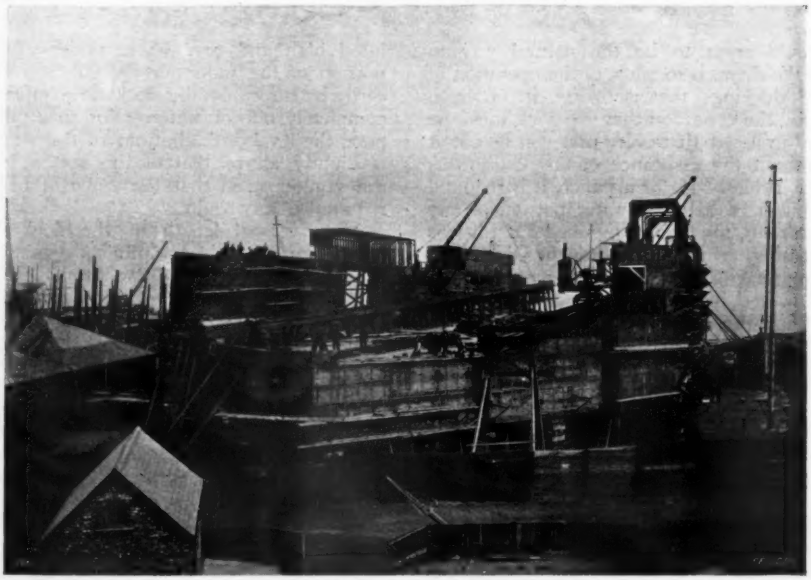
empty, the water is then pumped from the pound formed by the caissons and the deck of the dock, and the vessel is left quite free from water in what might be termed a graving dock, which has a depth of only about 8 ft. There are several slots into which the caissons may be fitted according to the length of the ship, and thus the amount of water to be pumped out is reduced to a minimum. As the greater part of the lift is done before the caissons come into play, and their depth, consequently, is very small, it follows that they can be made very simple, light structures. They, on this account, also obstruct very little light or air from the ship on the dock.

In order to make the joints between the pontoons watertight, strips of steel plate are bolted to the ends of contiguous pontoons with strips of rubber-sheeting underneath. These watertight joints are carried up to the tops of the altars on each side.

The pontoons are five in number, and are separate from and lie wholly between the two walls to which they are attached by means of heavy angles riveted to the walls and to the pontoons, which are connected together by fish-plates.

In order to withstand the great strain which would be thrown upon the connections between walls and pontoons during the shoring and lifting of a ship, tending to force the walls apart, and also the strains thrown upon them during the passage across the Atlantic, the plating of the pontoons at their sides was carried up 8 ft. 9 ins. above the pontoon deck; the deck plating being similarly carried up, so as to form an altar 2 ft. 3 ins. wide at the top, and 6 ft. 6 ins. at the bottom, and the upper attachments to the wall are carried up to the top of this altar. In addition to the strength which this arrangement gives, it also adds considerably to the stability of the dock at the time when this is most required.

The reason that the pontoon and walls are not made all in one structure, which



THE HAVANA DOCK IN COURSE OF CONSTRUCTION.

THE HAVANA DOCK IN COURSE OF CONSTRUCTION.

would seem to be the natural way to make them, is to allow of the operation of self-docking; that is to say, in order to fulfil the condition that the dock must be so arranged that every part can be got at without the assistance of any extraneous appliances. If, for instance, it is required to inspect the under-water portion of any pontoon, the dock is pumped out till it is floating at its light draught line, and any one of the pontoons may then be detached by knocking out the pins which attach the fish plates before referred to to the angles on the pontoon and walls. The pontoon then floats free. If the rest of the dock be now sunk, the free pontoon can be re-attached to the dock by connecting the lower attachments of the pontoon to the upper ones on the walls. If now the dock is pumped up again, it will bring with it the pontoon to be docked and lift it completely out of the water. Or, instead of attaching it to the walls, the free pontoon may be moved along and allowed to rest on the top of the altars on the next pontoon, and so be lifted high and dry. The under-water portion of the walls may be got at very easily by careening the dock until one is completely out of water. For this purpose. the level of the bottom of the walls is slightly above that of the bottom of the pontoons, so that the angle of heel required is very slight.

The over-all length of the dock is 450 ft., and the clear width between the altars 82 ft., and the depth over blocks 27 ft. 6 ins., the depth of water required for the dock is 42 ft. 6 ins., and the free board of the walls 4 ft. 2 ins., under these conditions.

The pontoons, as stated above, are five in number, the three middle ones being rectangular, and the two end ones pointed at one end. The width of all the pontoons is 87 ft. 11½ ins., the length of the rectangular ones is 75 ft. each, and that of the pointed ones 108 ft. 4 ins., a space of 2 ft. being left between each pontoon.

The walls have an over-all length of 383 ft. 4½ ins., and a width of 9 ft. 2½ ins., and a moulded height of 44 ft. 2½ ins.

The interior of both the walls and pontoons is stiffened by frames riveted to the skin-plating and by plate bulkheads. These bulkheads divide the dock into thirty watertight divisions for pumping purposes, each division having its own suction-pipe and air-pipe. Underneath the keel-blocks on the pontoons runs a longitudinal watertight bulkhead, which takes the weight of the ship when lifted and distributes it over the other portions of the structure. In short, it may be said that the interior of this dock does not differ in any essentials from that of many other well-designed floating docks, and it is hardly necessary here to go minutely into the internal arrangements.

In each wall of the dock there is a complete machinery installation so arranged that in the event of a breakdown of the motive power on either side, the whole dock can be pumped from the opposite wall without any difficulty. This installation consists of a locomotive boiler, which supplies steam to a compound vertical engine, to which is directly coupled a dynamo. In each wall there are five motors, each of 30 horse-power. These motors are vertical and drive direct on to the shafts of five horizontal centrifugal pumps, each of 12 ins. effective diameter. These pumps are placed right down at the bottom of the wall so as to rely as little as possible upon suction, thereby dispensing with foot valves. These pumps discharge out on their own level through the skin plating, their orifices being thus always below the level of the water. The pumps are placed on the top of a short cast-iron main drain, from which branch the distributing pipes, each one governed by its own valve. There is a separate pipe to each watertight division of the dock, or thirty in all, so that the regulation of the dock is under the most complete control. The rods from the valves which govern the water in each compartment are carried up to the top deck by means of levers, and are all worked from the central valve house on each side of the dock. In these two valve houses are also situated the switches for governing the motors, so that the man in the valve house has not only the motors under his direct control, but also the manipulation of every valve, so that he can regulate the whole dock, when either lowering or raising a vessel, without having to move from his post.

The berthing arrangements on this dock are very complete, everything necessary for speed and safety being found upon it. At each end of the walls of the dock are steam capstans for warping vessels into position, and for centering the ship when in between the walls of the dock previous to lifting there are two pairs of self-centering shores provided. These shores consist of heavy timbers contained in recesses in the walls. They are fitted on their under sides with a rack, which is actuated by a worm worked from the top deck. Each pair is geared together across the dock so that they work in and out simultaneously, and when each bears against the sides of the ship her keel will be found to be exactly in the centre of the line of keel blocks, and then side shores can be fitted in the ordinary way. The painting stages and altar tops are provided with cast-iron shoes to take the heels of these shores. In addition to the side shores, sliding bilge shores are provided. These consist of a lower portion of wrought iron, which can be placed anywhere on the deck of the dock, and therefore, if found necessary, may be concentrated under any special part of the ship which may be in want of extra support, and a timber sliding part which is in the form of a wedge, which is hauled in under the bilges of the ship by means of chains worked from the top deck. There are forty-six of these in all. The keel blocks are of pitch pine with oak capping pieces, and are spaced every 2 ft. 1 in. over the whole length of the pontoons.

At each side of the stern end of the dock there is a light swinging gangway fitted at the end of the walls, which serves both to establish communication between the two walls, and also as cranes for dealing with propellers or other heavy weights that may be required to be lifted on or off the dock. They are each capable of lifting 15 tons.

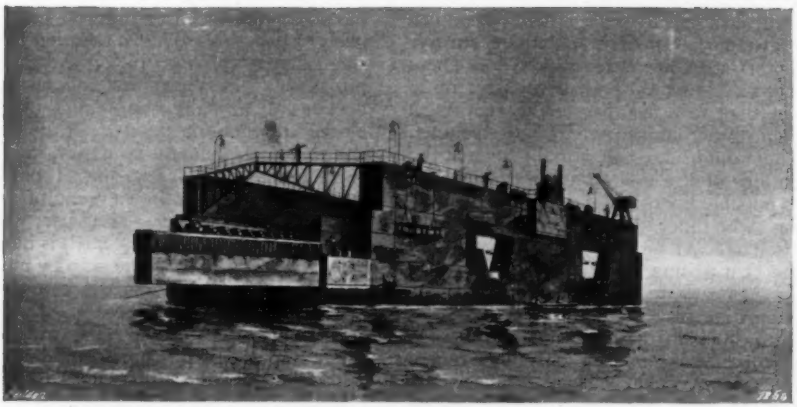
The dock is fully equipped with minor fittings, such as cleats, ring-bolts and

mooring bitts, with a complete installation for the electric light.

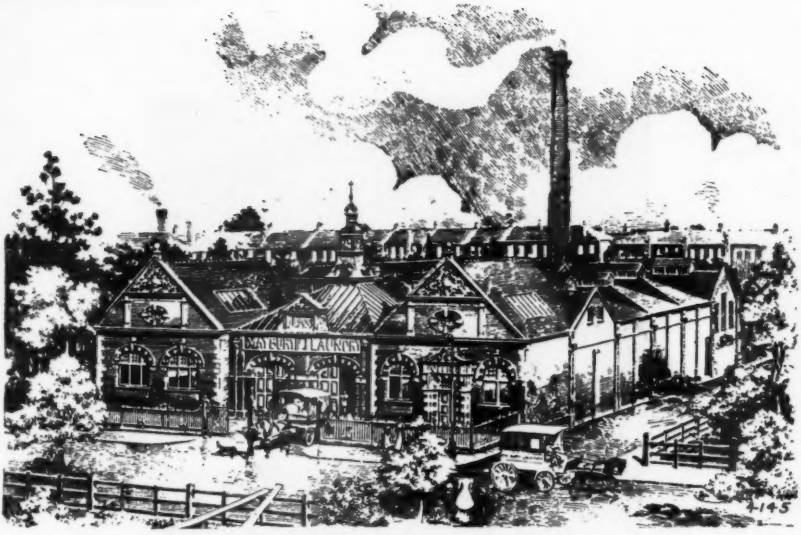
The voyage to Havana was completed without mishap in fifty-eight days, or at the average rate of four knots. The dock was fitted with a rudder, which, although apparently of some service in the narrow and winding Tyne, was found to be of no practical utility; and in later docks, which have had to be towed, this feature has been discarded, as also has the rigging of docks with masts and sails intended to be of service in the region of the trade winds.

It is generally rash to prophesy, but it really appears that, as Stevenson's "Rocket" was destined to be the forerunner of a universal system of land travelling, so the Havana dock may in the future be looked upon as the parent of a universally adopted system of docking ships.

S. F. Staples



FLOATING GRAVING DOCK LIFTING ONE OF ITS OWN PONTOONS.



Laundry Engineering.

By F. J. ROWAN, A.M.Inst.C.E.

(Continued from page 530, Vol. VI.)

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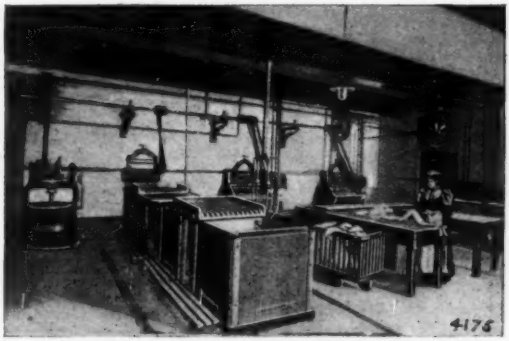
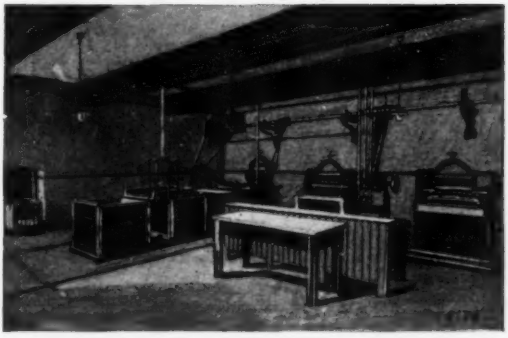
In considering the buildings required for laundry work they may be divided into three groups, viz.: (1) Private laundries, which are usually small; (2) public laundries, or those erected for laundry companies or firms engaging in laundry work commercially; and (3) laundries of public institutions, which are usually large. It is, however, impossible to fix any very definite limits of size for each group, because in that respect examples from the various groups may overlap one another, so that there may be a large laundry attached to a private mansion, almost any range of size in group 2, and a comparatively small laundry attached to a small hospital or other public institution One or two typical examples of each group will give a sufficiently general idea of them all.

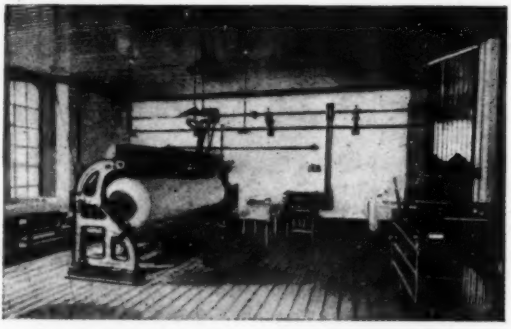
The external architecture of the buildings is usually decided by the taste of the architect, regard being had to the surroundings in which the laundry is placed, and to the design of the adjacent buildings, if any exist. As, however, nearly all laundry buildings are situated in more or less suburban localities, in order that they may be free from smoke and dust as much as possible, it follows that anything like the severely plain style usually adopted for factory buildings should be avoided.

From the point of view of economy of labour, it is desirable that all the work should be carried out on one floor, although it is not imperative that such an arrangement should be adhered to. It would be possible to arrange a convenient laundry upon two floors, the clothes being carried up and down by means of elevators.

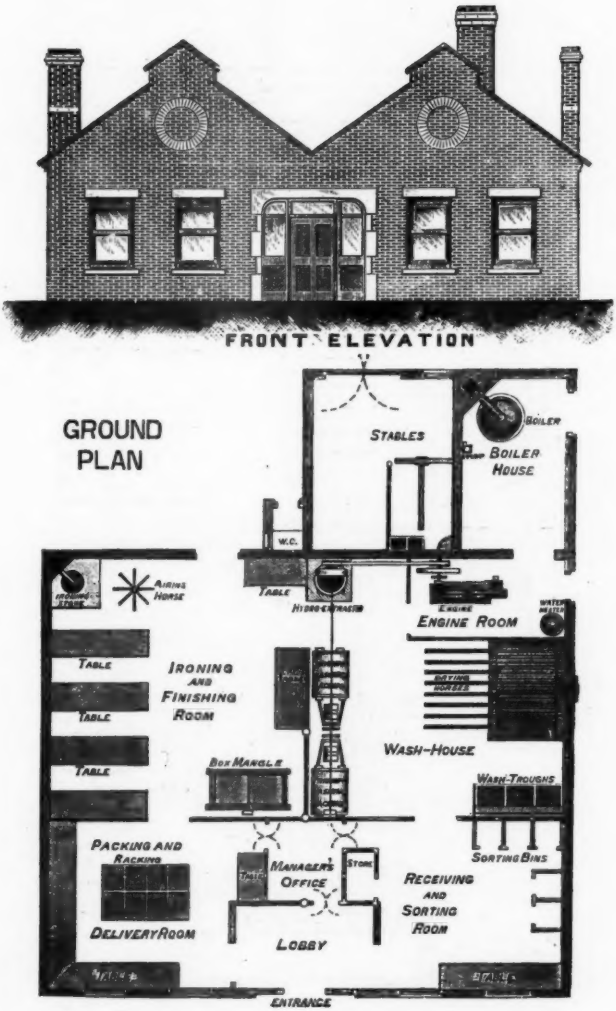
One feature in the internal arrangement that is imperative, however, is the separation of the washing or cleansing and the ironing or finishing departments, so that



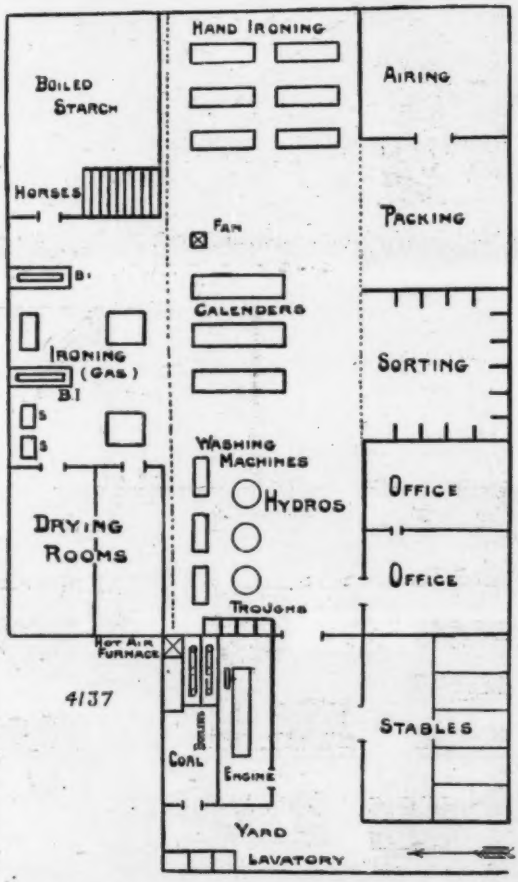




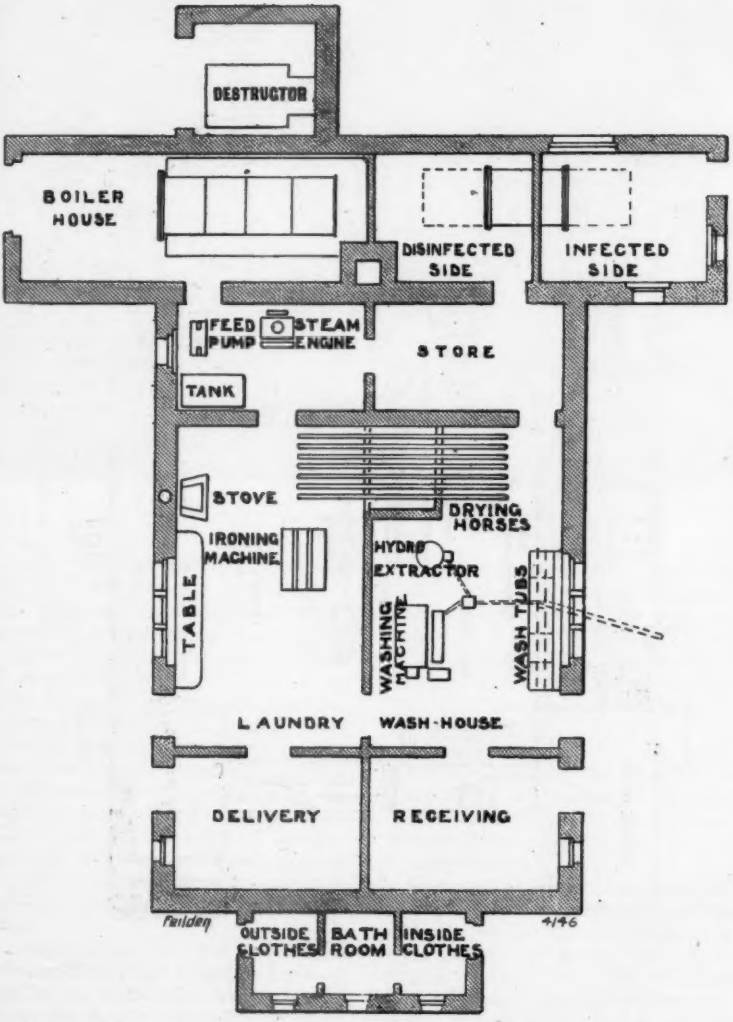
VIEWS IN THE ELECTRIC STEAM LAUNDRY AT WYNYARD PARK.



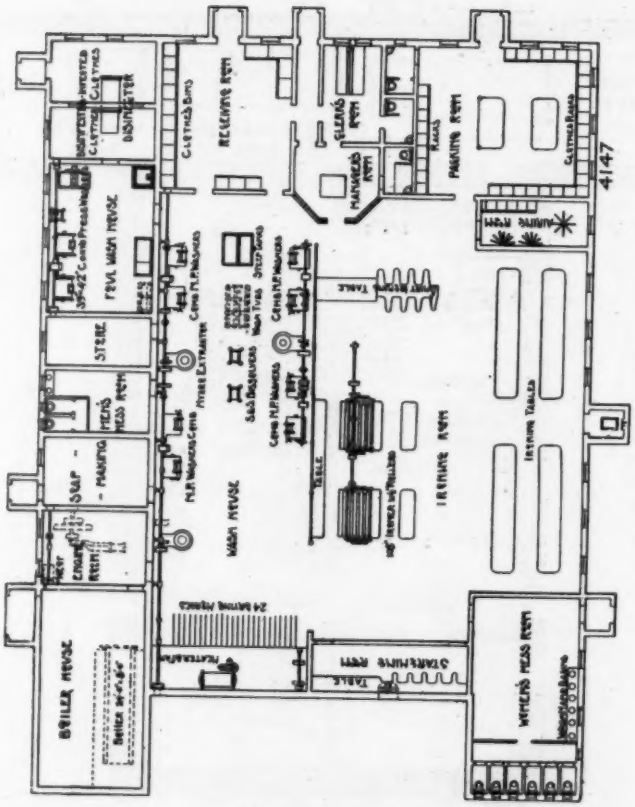
DESIGN FOR SMALL STEAM LAUNDRY BY MESSRS. W. SUMMERSCALES AND SONS, LTD.



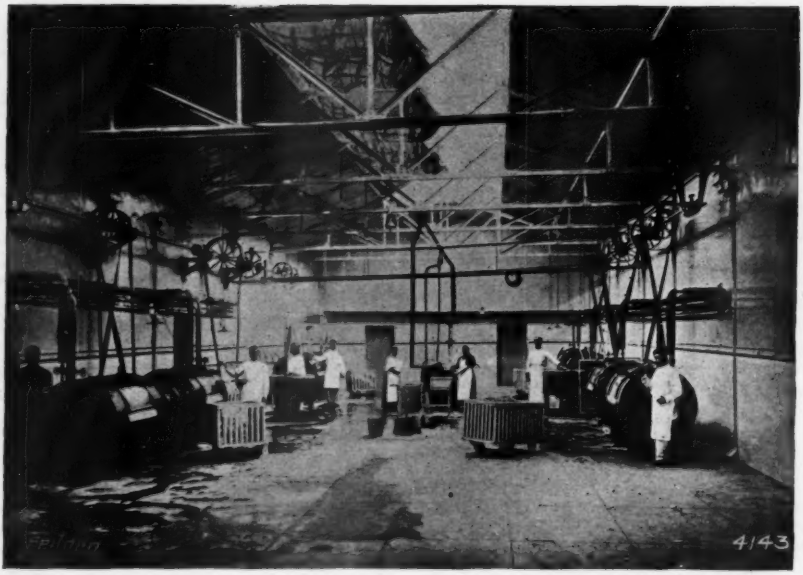
PLAN OF LAUNDRY, BY MR. A. S. E. ACKERMANN, A.M.INST.C.E.



PLAN OF STEAM LAUNDRY FOR SMALL HOSPITAL



PLAN OF HOSPITAL LAUNDRY AT ODESSA.



MUNICIPAL STEAM LAUNDRY, ODESSA: VIEW OF WASH-HOUSE.

it is usual to find laundry buildings arranged in the form of two or more parallel bays or sheds, divided by a partition wall, with a roof over each. In the case of hospital laundries, an additional department is often required in order to deal with infected clothes; and sometimes another is also added, where the establishment is a large one, for the purpose of washing and ironing the clothes of the officials alone. In such a case the frontage may embrace four spans of roof; but of course the details of internal arrangement will necessarily be affected by the extent and shape of the ground which is available for the erection of the laundry.

It is readily understood that an essential requirement of all good laundries is plenty of light in the workrooms, and it is this condition which has caused the architecture of steam laundries to be restricted in the main to buildings of one storey in height, the roof being naturally the point at which the greatest diffusion of light can best be arranged.

The smallest size of private laundry consists only of washing-house and drying and ironing room, and is arranged with machines worked by hand-power only.

The private laundry shown in the figures on page 108 is in complete contrast with that of the smallest size of private laundry, being not only worked by power, but also on account of its size and completeness and the fact that the machinery is all run by means of electricity. These views are inserted by permission of Messrs. Thos. Bradford & Co., who fitted up this laundry.

Commercial steam laundries and those attached to public institutions should be arranged so that there should not be any cross-currents of goods, but all should progress steadily from the receiving and sorting rooms, through the various machines in turn, to the packing and delivery department. A compact design for a small commercial laundry which is so arranged is shown in the figure on page 109, which is borrowed from Messrs. W. Summerscales & Sons, Ltd.; whilst in

the figure on the following page we have a ground-plan of another design, which is not so well arranged in this respect.

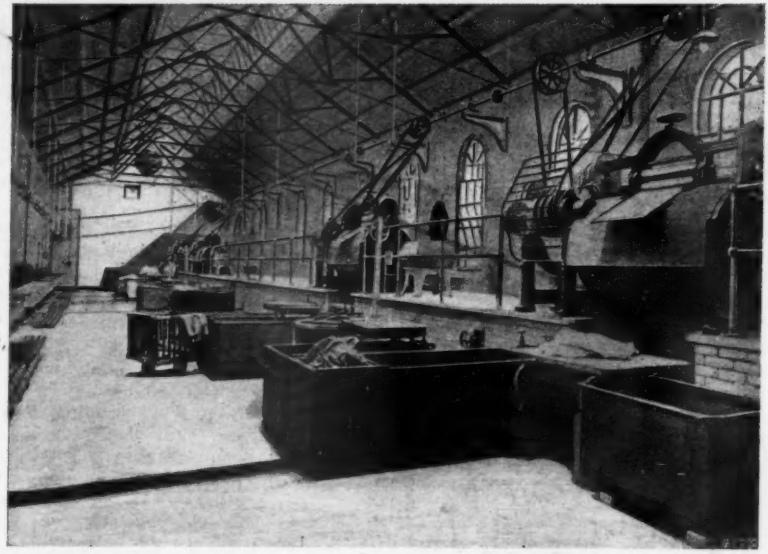
One of the largest commercial steam laundries in the kingdom is shown in the headpiece to this article, which affords a view of the buildings in perspective. The sorting room is 54 ft. by 31 ft., the washing room 95 ft. long by 25 ft. wide, and the ironing room 95 ft. by 69 ft. The airing room is 29 ft. by 27 ft., and the covered courtyard at the entrance is 36 ft. square by 16 ft. high to the apex of the glass roof. Seven large washing machines, four hydro-extractors, 14 washing troughs for special articles, two sets of drying apparatus, and two large steam mangles, besides starching and other machines, make up its outfit, the equipment having been carried out by Messrs. James Armstrong & Co., Ltd.

The figure on page 111 shows an arrangement for a hospital laundry on the smallest scale, designed by Mr. Thos. Young, consulting engineer, on similar lines to that of the Dumbarton Joint Hospital, of which he is the engineer. Mr. Young has designed several large hospital and public laundries, but he was kind enough to meet the writer's request for a sketch of one on a small scale.

Of large laundries for hospitals or public institutions, the one erected by the municipality of Odessa (of which the plan is shown on page 112) may be taken as a good specimen. The two succeeding illustrations give views of the internal arrangement of different departments. These illustrations have been supplied by Messrs. D. & J. Tullis, who equipped this laundry.

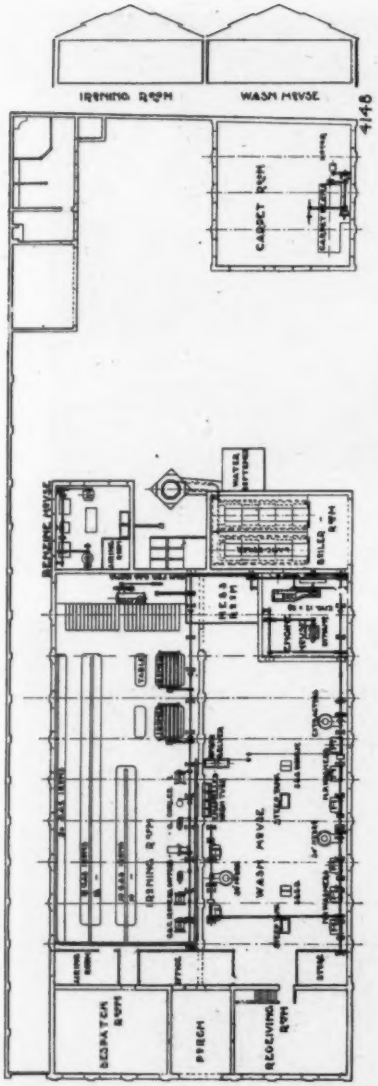
On this point of the internal arrangements, the views on page 115 illustrate a plan adopted by Messrs. Thos. Bradford & Co., which has the recommendation that it removes the machines out of the reach of any unskilled people who may be employed in the laundry. It consists in placing the machines on a platform which runs along one of the side walls. In the case of washing machines, as shown in the top view, the

THE IRONING ROOM IN THE ODESSA LAUNDRY.



BRADFORD'S PLATFORM SYSTEM: WASHING, TIPPING, BOILING, RINSING, AND WRINGING APPARATUS.

BRADFORD'S PLATFORM SYSTEM: WASH-HOUSE, COUNTY ASYLUM AT PRESTWICH.

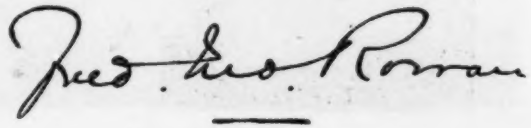


PLAN OF THE ALEXANDRA STEAM LAUNDRY, HULL.

washed clothes are tipped from the machine on to the drainer below, and as that is made capable of travelling along the front of the platform, handling the clothes is rendered almost unnecessary. In the lower view, which shows an arrangement got out for a county asylum laundry by this firm in 1883, the washing machines are shown on the platform, with a large wringer provided for each below.

The plan of the building for the Alexandra Sanitary Steam Laundry, Hull, prepared by Messrs. D. & J. Tullis, and shown on this page, presents some differences in detail, and may be taken as a fine specimen of a well-arranged laundry of considerable size. A benzene house for "dry" cleaning operations and space for a water-softening plant are included in this plan.

(To be continued.)



British and American Mining Machinery on the Transvaal Goldfields.

By P. J. N. FOWLER.

It is probable that at no other mining centre are mining machinery manufacturers of all nationalities so well represented as on the goldfields of the Witwatersrand. Especially may this be said in reference to machinery of British and American manufacture.

The representatives of each are always on the alert for any improvements or new ideas which may be forthcoming from the many experiments conducted and experience gained in the working of existing plants, and speedily advise their principals at home of such new ideas, with suggestions as to the best possible means of having these embodied and arranged for in future orders.

By such means these goldfields possess the finest machinery in the world for gold-mining and ore-dressing purposes, which has been specially designed and erected for working the ore under the most efficient and economical conditions.

As all machinery required for these fields is thrown into open competition, and equal facilities and conditions given to all for tendering, competition is very keen, prices are naturally reduced to the lowest limits, and any particular merit or advantage in construction, material, or manipulation is made the most of. Drawings and photographs of the proposed or similar plants are usually attached to the specifications and tenders sent in by the competing firms; selections are then made, after careful consideration of the respective merits in connection with cost, weights, and time of delivery, this latter item being of great importance.

It is not possible in the present article to discuss or compare in detail the respective merits of the various English and American manufactures—such an article might well be written on any one item—so that only the more important items which constitute the surface equipment of a mine, otherwise known as the mining and ore-dressing plant, will be mentioned and their chief points discussed. It will be well to give first a general outline of the most important machinery in use on the fields, and to deal afterwards with the competitive merits of each.

The motive power in every case being steam, boilers will receive first consideration.

BOILERS.

The boilers most in use are of the tubular type, represented on the British side by Babcock & Wilcox, British-made Stirling and Heine, Dryback multitubular and Cornish multitubular; on the American side by American Stirling, Roots, and other kinds of multitubular boilers by various individual makers, built in batteries of from 100 h.-p. to 400 h.-p. units, with working pressures of from 100 to 140 lbs. per square inch, the furnaces, or length of fire grate, being made extra large for burning the Transvaal coal, which, until recent years, was of poor quality. It is now possible to obtain Middleburg* coal on all parts of the Randt, at a fairly reasonable price; but even the coal from this district does not equal the Welsh coal for steam-raising qualities.

WINDING ENGINES.

Winding engines are of two classes or types, geared and direct acting, and range in size from a 6-in. diameter cylinder by 10-in. stroke, of the former, to compound 28-in. and 50-in. diameter cylinder by 72-in. stroke of the latter type.

Cylindrical drums are most commonly in use on both types, although "reels"

* A coal district E.N.E. of Pretoria, on the Delagoa Bay line, supplies the best coal in the Transvaal.

for flat ropes have been installed in one or two instances, and conical drums are being anticipated in the near future.

On "outcrop" properties, "incline shafts" are generally sunk, and geared winding engines have been mostly installed, of about 12-in. and 12-in. diameter cylinder, 24-in. stroke, to 15-in. and 15-in. diameter cylinders, 30-in. stroke. With these shafts not going to any great depth, quick winding, with heavy loads, is not so important. These engines have been found quite suitable for depths of about 1,500 to 2,000 feet, with loads up to 5 tons, including weight of ore, skip, and rope. On "deep levels"—vertical shafts—mining has to be carried on at depths of 3,000 feet and over; in such cases large direct-acting engines of a very powerful type—*i.e.* fitted with steam-brakes, clutch, and reversing gear—have been installed, as it is necessary with the deeper mining to haul heavier loads at increased rates of speed. Some attempts have been made to balance the weights of the ropes, when winding from these great depths, but so far with doubtful results

SINKING ENGINES

are a smaller type of winding engine, and are generally used, as their name implies, for shaft sinking, lowering timber, and general repair work to shafts and pumps.

DRIVING ENGINES.

Driving engines may be taken to include both the large and small sizes, used generally for mine and other pumping, driving crushers, sorting appliances, stamps (batteries), etc. These are generally of the horizontal compound condensing Corliss type, either tandem or cross compound (with surface condensers) of from 30 h.-p. to 1,100 h.-p., and mostly drive by ropes or belts. In some cases they are direct-coupled to the driven machinery.

ENGINES AND ELECTRICAL PLANT.

Generators are now being installed, almost universally, of the three-phase alternator type, with engines coupled direct. Until recently, however, direct-current machines were much adopted, either belt or rope driven, or direct coupled to engines.

The engines are of the high-speed type, by many well-known makers; with the three-phase type slower speed engines are made available.

Each mine has its own independent electric generating station, the current, being used for lighting all surface works and the "stations" underground, also for pumping from the mines and reservoirs, and, in a great many cases, for running isolated plants, *i.e.* pumps, etc., in the cynanide works, machine shops, small hoists, mechanical haulages, etc.

AIR COMPRESSORS.

Air compressors of the cross-compound steam and air cylinder type are generally preferred, ranging in size from 20 to 45 drill capacity. On account of the high altitude, about 6,000 feet above sea level, these have to be made much larger, in order to do the same duty, than those installed near the sea level.

CONDENSERS.

Surface condensers are mostly favoured to jet condensers, although on many mines the water is fairly good and free from acid, and there should be no reason against using jet condensers in such cases.

BATTERIES OR STAMP MILLS.

The battery ironwork is imported ready for erection of some well-known makers' standard designs; in some cases, special designs to suit individual ideas and local conditions are required. The wood framing for bins, building, etc., is framed on the spot; it has been found more satisfactory to do this, to suit the many varying conditions, than to import the timber ready framed for erection.

CYANIDE PLANTS.

The cyanide plant usually consists of double treatment tanks, the upper ones or row being used for "settling," and are a little shallower than the bottom tanks. The top tanks are supported on columns and staging, the former of cast-iron or structural steel, the latter composed of rolled sections.

The bottom tanks are supported, either on masonry or short columns, about 6 ft. above the ground level.

The tanks are of steel, about ¼-in. thick, from 30 ft. to 40 ft. diameter by about 10 ft. deep—usually about 12 ft. to 30 ft. diameter. Treatment tanks are required for a 60-stamp crushing plant.

The materials are imported with all plates and angles cut to sizes, rolled to shape, punched, marked, and ready for riveting up, including columns and girders.

The erecting and riveting is contracted for by local firms, who make a speciality of this class of work.

ROCK BREAKERS.

The rock breakers in use are either the rotary or reciprocating type, and are used to break the rock coming from the mine, from about 6-in. to 2-in. cubes, before being conveyed to the battery to be crushed to sand by the stamps.

COAL CARS.

A great many of the mines are laying down sidings connecting up to the main line of railway and intend using large hopper coal cars, thus getting their coal in bulk, which will prove a great deal cheaper in every way than the old form of having it brought in by ox-waggons, in bags, from the nearest railway station.

With this summary description we may now proceed to deal with the main point of the article.

Turning now to the Table of Comparisons (see p. 120), and taking each item in order, a few brief remarks on the chief points of each must suffice.

BOILERS.

British makers undoubtedly produce the better class of boilers in every way, using slightly heavier plates, better staying, and, what is more important, drilled rivet holes—usually plates drilled in place—and also a better class and style of boiler fittings or mountings.

American manufacturers generally punch and then ream the rivet holes, and use a great amount of cast-iron in their "trimmings," this practice, together with lighter plates, enabling them to quote a lower price. Notwithstanding this, boilers of British manufacture are preferred, and most largely installed.

WINDING ENGINES.

The deep shafts of the copper mines in the Lake Superior district, U.S.A., with their demands for heavy-duty, quick-winding engines, have undoubtedly developed American practice in this line. Their engines are more easily controlled and better designed than those of British manufacture, and at the same time are heavier and lower in price per unit. The great advantage lies in the complete control of the engine by one lever, which operates the throttle, steam brakes, and in some cases the reversing gear. The driver's platform is raised high above the cylinders, giving a clear and unobstructed view (see Figs. 1 and 2).

In the English make the platform is, at the most, only about 4 ft. or 5 ft. above the floor, generally on the floor level, the driver having to operate from three to four levers to control the engines, and can scarcely see over the drums.

In reference to build of engines, see remarks under driving engines.

SINKING ENGINES.

The great variation in price and weight of these must be due to the variance in style quoted by the respective makers, the British manufacturer quoting on a geared type, the American manufacturer on a direct-acting type

Undoubtedly the direct-acting engine, even for small work of this class, is much to be preferred on account of fewer wearing parts, absence of noise and vibration, and consequently less wear and tear, meaning thereby less cost in stores and maintenance. Although higher in price than the geared engine it should soon re-pay the difference of initial cost. The cost of foundations for this engine would be less, as also would be the floor space.

DRIVING ENGINES.

Small and large driving engines may be grouped together under the one head for consideration, as the same remarks will apply equally to each. British and American manufacturers possess about equal merits on these, except in about two instances, viz., valve gears and frame.

Valve gears of the Reynolds Corliss' type, with vacuum dashpots, as fitted by

COMPARATIVE TABLE SHEWING AVERAGE WEIGHTS, COST, AND TIME OF DELIVERY OF

BRITISH and AMERICAN MACHINERY,

for Mining and Ore Dressing Purposes, in use on the Witwatersrand Goldfields.

Description of Machinery.	Unit of Comparison	British			American.			Remarks.
		Weight per Unit.	Cost per Unit.	Time of Delivery.	Weight per Unit.	Cost per Unit.	Time of Delivery.	
Boilers - -	per sq. foot of heating surface.	26 lbs.	s. 8·16	120 days.	22 lbs.	s. 7·82	130 days.	Water Tube Boilers, of 140 lbs. per sq. inch working pressure. British Makers have some on hand and could start delivery at once.
Engines, Winding	per ft. ton raised per minute.	17·8 lbs.	s. 8·39	7 mths.	18·2 lbs.	s. 9·48	8·3 mths.	Direct-Acting Engines. American special Conical Drums. British Cylindrical Drums. Steam Reversing and Brake Gear. Weight of Hauling Rope neglected in unit.
Engines, Sinking -	per foot of depth sunk.	37·3 lbs.	s. 12·3	—	20 lbs.	s. 16 2	210 days.	American Direct-Acting Engines. British Geared Engines. Cylindrical Drums, 2 h.-p. Cylinders, load 3,000 lbs., neglecting weight of Rope.
Engines, Small driving	per sq. in. of h.-p. cylinder area.	lbs. 306·5	£8·3	130 days.	lbs. 368·3	£9·45	130 days.	American Corliss Valves. British Slide Valves, Expansion Valves on h.-p. Cylinder. Tandem Compound Engines, no Condenser.
Engines, Large driving	per sq. in. of h.-p cylinder area.	lbs. 461·9	£16·77	180 days.	lbs. 530·4	£16·31	190 days.	Corliss Valves in each instance, Cross-Compound Engines, including Surface Condenser.
Electrical Plants -	per k.w. of output.	—	£20·51	—	lbs. 372·3	£19·22	—	Three-Phase Alternators, with Compound Engines, coupled direct, including Surface Condensers, about 250 r.p.m.
Air Compressors -	per sq. in. of h.-p. air cylinder area.	lbs. 676·3	£16·40	—	lbs. 546·1	£17·83	—	Compound Steam and Air Cylinders in each case, including Surface Condensers, Coolers and Receiver. Air-Pressure, about 80 lbs. per sq. inch.
Condensers, Surface	per sq. foot of cooling surface.	17·3 lbs.	s. 14·8	182 days	10 lbs.	s. 10·01	180 days.	Admiralty Type.
Stamp Mill Ironwork	per lb. weight per stamp.	—	s. 1·268	100 days.	lbs. 3·615	s. 1·527	120 days.	Battery Ironwork, including Shafting Pulleys, Bearings and Couplings, exclusive of all woodwork and Belts.
Cyanide Plants -	per ton weight of material.	—	£26·73	200 days.	—	£22·42	60 days.	Steel Tanks and Staging, Structural Steel Columns, Plates all punched ready for riveting up, including all rivets.
Rock Breakers -	per ton of rock broken to 2-in. cubes per hour.	lbs. 1846·4	£32·9	75 days.	lbs. 1115 7	£19·9	84 days.	American Rotary Type. English Reciprocating Type.
Coal Cars - -	per ton of carrying capacity.	0·435tns. 0·458tns.	£14·107 £15·68	52 weeks.	0·41 tons. 0·36 tons.	£11·05 £11·26	20 weeks.	Hopper Bottom Discharge, Steel Cars. Flat Bottom Side Discharge, Steel Cars.

N.B.—Cost in all cases, except Coal Cars, delivered on Mines, Johannesburg. Coal Cars delivered at African Coast Port

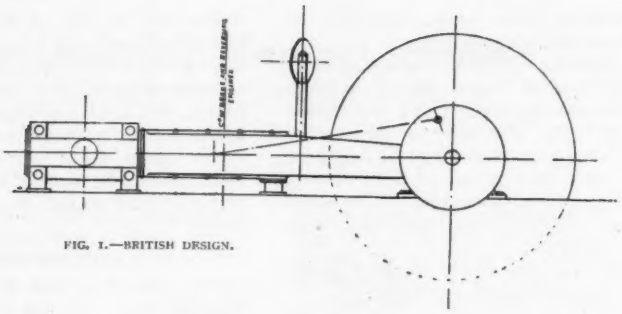


FIG. 1.—BRITISH DESIGN.

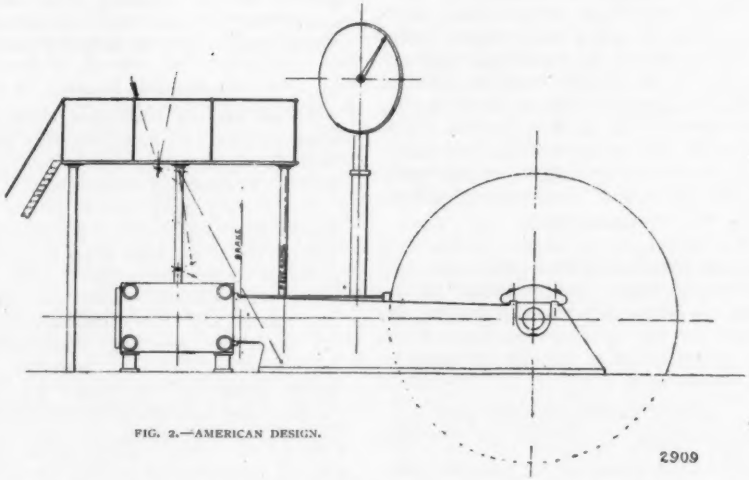


FIG. 2.—AMERICAN DESIGN.

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FIGS. 1 AND 2.—SHOWING DIFFERENCE BETWEEN BRITISH AND AMERICAN WINDING ENGINE PRACTICE.

the majority of American makers, are much to be preferred to the usual British practice with spring dash pots. The former has fewer wearing parts, is more positive of action, stronger, and easier of access for adjustment and repair.

As to frames, the American practice of forming the guide and main bearing into one large sole-plate is much better than the girder or middle-foot type of the British. (See Figs 1 and 2.)

The former gives the greatest strength, also greatest amount of metal. In mining work especially, engines are often called on to perform work much above their full load; the engines should, therefore, be of the heaviest consistent design throughout

The British makers can claim superiority in finish and fittings, especially as they do not detract from the appearance of a fine, powerful machine by the use of silver-plated fittings, which shew such rough work underneath when looked at closely, and look so much out of place.

The foregoing remarks apply equally to all classes of engines here considered.

AIR COMPRESSORS.

These show both by price and weight to be in favour of British. The remarks

just made *re* valve gears, especially as regards air-valves apply here.

The American practice of using a greater number of small valves allows of small clearance spaces, making the compressor more efficient. The wear on these small valves is not so great as might be imagined at first sight, on account of light moving weights and good cushioning. The valves are easily removed and reground to their seats when worn.

In this class the British makers' design is quite as good as the American.

SURFACE CONDENSERS.

Surface condensers show a wide divergence both in price and weight, being much in favour of American manufacturers. As regards the working of either make both seem to be of equal merits, and leave little to be desired, The American type occupies less floor space, and on account of lighter weight would cost much less landed here on freight alone.

STAMP MILLS.

A comparison of weights in this case was not possible, so that prices can only be taken, which are in favour of the British. So far, actual experience on the Randt of the wearing qualities of the two makers decides strongly in favour of the British type.

CYANIDE PLANTS AND COAL CARS.

It is difficult to account for the wide differences in cost of these two items. Cyanide plants being a new departure as far as America is concerned, and with no past experience on which a comparison can be based, such a wide divergence is startling, and especially so when American manufacturers quote lower prices for structural steel columns in place of cast-iron. British manufacturers quoted in quite the reverse order.

ROCK BREAKERS.

The great difference here is easily accounted for in the two types of breakers quoted on, the rotating type breaking nearly twice as much rock as the reciprocating type, weight for weight of machines.

ELECTRICAL PLANT.

British makers have paid little or no attention as yet to supplying this market, with three-phase machinery, so it is impossible to draw any comparison.

No doubt, many readers would have liked some comparisons of prices, weights, and merits of machine shop tools, manufactured by the two nations. The writer went very carefully into the subject, but found that comparisons could not be made in anything approaching a concise form, and was, therefore, reluctantly compelled to omit this much debated and interesting class of machinery from the present article.

Percy S. Fowler
4181

Modern Portable Engines.

By WILLIAM FLETCHER, M.I.Mech.E.

(Continued from page 56.)

THREE sets of indicator diagrams are given, taken from a simple engine, showing the action of the automatic expansion gear in varying the cut-off to suit the load, and maintaining the speed of the engine practically constant. Figs. 29, 30, and 31, show the cards.

We illustrate two portable engines manufactured by Messrs. Ransomes, Sims and Jefferies, Ltd., of Ipswich: the first, like Fig. 32, is of the single-cylinder type, fitted with a high-speed spring governor, controlling the speed of the engine by means of an equilibrium throttle-valve, the governor bracket being mounted on the valve-guide casting. Wrought-iron crank-shaft brackets are riveted to the boiler barrel. The two plates have a block riveted between them, on which the plummer block for the crank-shaft is secured, the studs for holding the bearings down have slotted holes for allowing a little end play, to admit of the boiler expanding or contracting without affecting the engine centres. Only one stay is provided, this being placed on the cylinder side: the fly-wheel side has no stay, so the plummer block is bolted down rigidly to its seat. This arrangement throws the crank-shaft a little out of square when steam is up, but the movement is so slight that no trouble is experienced. A ball-and-socket fore-carriage is used, and the engine is mounted on wrought-iron travelling wheels.

Fig. 33, represents a compound portable engine by Messrs. Ransomes, which is fitted with Hartnell's governor and automatic expansion gear to the high pressure cylinder. It will be seen that the valve chests are placed outside, enabling the slide valves to be more readily reached for examination or repairs. The exhaust-pipe is flattened beneath the crank-shaft for giving clearance for the crank dips. In the present example the crank-shaft bearings are mounted on wrought-iron horn-plates, as shown clearly in the accompanying sketch, Fig. 34. The two fan-shaped plates are riveted to the boiler barrel, the space between the plates is filled up with a packing piece of sufficient width to receive the crank-shaft bearing, the top of the horn-plates and the plummer block are both planed, to raise the crank shaft the correct height above the boiler top. In the compound-engine a stay is provided on each side, and provisions are made for each bearing to slide, to allow for the expansion and contraction of the boiler. The boiler is of the flush-top type, and is lagged from end to end, the boiler is made for working at 140 lbs. steam pressure.

Fig. 35 shows Messrs. Ransomes' automatic expansion gear. In this apparatus, an independent gridiron expansion valve, working upon the back of the main valve, is operated through a knuckle-joint by a link, one end of which is actuated by a cut-off eccentric, while the other end is held by a radius rod. The travel of the valve and the points at which it cuts off are governed by the position of the link in relation to the knuckle-joint; and this position is varied in accordance with the load on the engine for the time being, by a powerful and sensitive governor of the Hartnell type, to which the link is connected. By this arrangement the cut-off is varied between 0 and 70 per cent. of the stroke, in proportion to the actual load on the engine: the exact amount of steam necessary to do the required work is admitted at full boiler pressure up to the point of cut-off.

The diagrams illustrated by Fig. 36, are taken from a 10-h.-p. nominal engine, working at 80 lbs. pressure, and show how the cut-off is proportioned to the load on the engine.

A small compound-tandem portable engine is made by Messrs. Riches &

FIGS. 29, 30, 31.—DIAGRAMS SHOWING ACTION OF HARTNELL'S AUTOMATIC EXPANSION GEAR.

Watts, of Norwich. The low-pressure cylinder, slide-bars, and crank-shaft are carried by a light casting, as shown; the high-pressure cylinder is overhung and connected to the stop-valve by a small pipe. The engine is fitted with a shaft governor acting directly on the slide-valve, allowing the pressure of the steam in the boiler to be used to the greatest advantage. The expansion of the steam is regulated automatically to the work required. This type of engine is very light, an 8-horse engine can be readily shifted by one horse. Though light, it will develop three times the nominal horse-power. In passing, we may remark that agricultural engineers have been urged to make lighter engines for working at higher pressures, and quicker speeds. The suggestion is in keeping with the spirit of the times: pressures are rising, speeds are being augmented; but, curiously, the portable engines made to harmonise with the above conditions did not take well with buyers; and, as sales were not easily effected, the manufacture ceased. It is quite true that the working pressure is gradually creeping up, the portable engines of some of the makers are intended for using steam of 100 lbs. pressure. While this is going on, the sizes of the engines are not being reduced in the same ratio, but they remain the same size as heretofore; and of course are made heavier to bear the augmented working steam pressure.

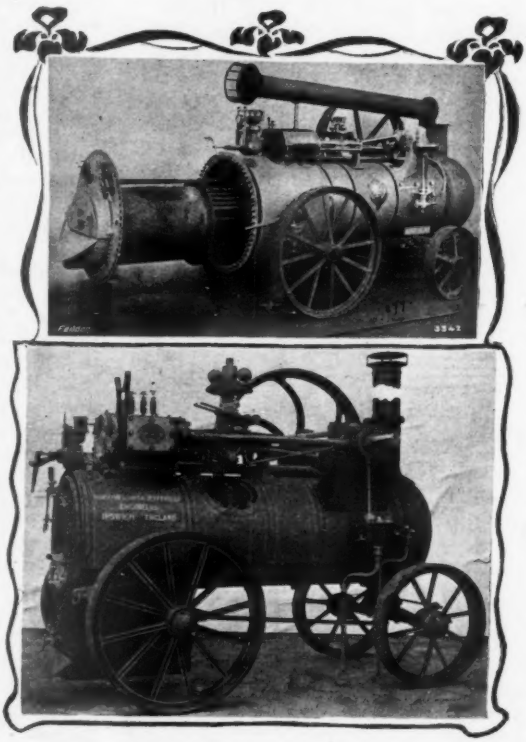
Fig. 37 (p. 49) illustrates a new type of portable engine made by Messrs. Robey & Co., of Lincoln. It is fitted with wrought-iron crankshaft brackets, the cylinder and stop-valve castings are also provided with planed seatings. Two stays connect the cylinder to the crankshaft bearings; near the centre the stays carry a cast-iron bridge plate, which serves as a support for the ends of the guide bars, the governor, and valve gear, the pump and valve boxes. A casting near the cylinder serves as a stop-valve box, and steam inlet to the cylinder; on the top of the casting a Ramsbottom's safety-valve and pressure-gauge are mounted. The engine is fitted with a powerful governor regulating a cut-off slide-valve on the back of the main valve, by means of a slotted link. Figs. 38 and 39 shew the automatic expansion gear: the balls of the governor are attached to bell crank levers, and the ends of the short arms of the levers are provided with friction rollers, which press on a cylindrical disc fitted to the spindle. As the speed increases, the balls fly out, depressing the ends of the short lever arms, and so compress the spring; the motion of the sleeve being communicated by links and levers to the die in the slotted link, in a similar manner to the gears already illustrated.

A double-cylinder engine is illustrated by Fig. 40, the small high-speed governor is mounted on the cylinder, and acts on a throttle-valve for regulating the speed of the engine. A cast-iron bridge-plate is carried on the two stays, which in its turn supports the slide bars. The pump in the present instance is bolted beneath the crankshaft. A ladder and platform are provided, as shown: the engine is mounted on wrought-iron wheels.

Fig. 41 represents a portable engine

made by Messrs. Robey & Co., having a cylindrical multitubular boiler with a draw-out fire-box and tubes. For certain districts in Europe this type of boiler is supplied. By unscrewing the nuts round the front plate, and others securing the tube-plate at the smoke-box end, the furnace with the tubes and front tube-plate can all be withdrawn together from the boiler shell, for the purpose of cleaning out the boiler, after which they may be replaced. A hand-feed pump is shown, and it will be seen that the engine is fitted with the automatic expansion gear just described. Portable engines of this type are made by other firms.

Mr. A. S. F. Robinson is the inventor of a powerful governor which is placed inside the fly-wheel, as shown by Fig. 42. The arrangement of the governor is new, the absence of all working joints, and the positive connection to the moving parts are valuable features of the governor possessed by no other. The following is quoted from Mr. Wilson Hartnell's report:—"The advantages secured are: the absence of working joints, the maintenance of accurate adjustment, besides being free from play and perfectly silent, without the necessity of very accurate fitting. The means of adjusting the speed whilst the governor is in motion is often a great convenience, especially in electric lighting. Although there have been many forms of shaft governors, this governor combines new features; it has sufficient ingenuity exercised upon it to constitute a novel and useful invention." The perfect action of the governor is seen by the diagram, Fig. 43, from a seven h.p. portable engine with the load on and off at 80 lbs. steam pressure, the governor acting on an ordinary unbalanced slide-valve. The governor is completely enclosed within the fly-wheel, thus really completing the duty of the fly-wheel, which in addition to controlling the turning movement of the crank, should—and by this invention does—regulate the speed of its rotation in a perfect manner. It will be seen that the slide valve is worked by means of a rocker casting, one side of which is connected to the eccentric rod and the other to the slide rod.



FIGS. 33 AND 41.

Messrs. Ruston, Proctor & Co., Ltd., of Lincoln, are manufacturers of the portable engine represented by Fig. 44. The cylinder is mounted on a steel seating riveted to the arch-plate of the boiler. The crank-shaft brackets are made of wrought-iron, as shown; the

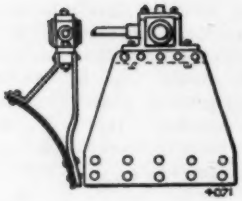


FIG. 34.—SHOWING METHOD OF MOUNTING CRANK-SHAFT BEARINGS ON HORN-PLATES.

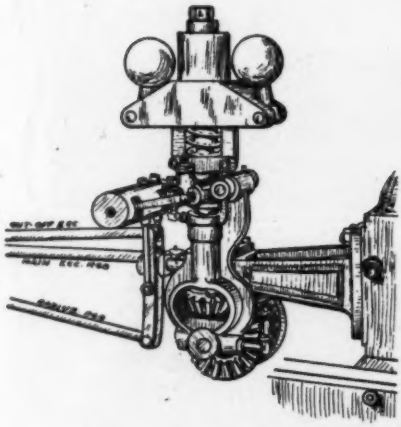


FIG. 35.—MESSRS. RANSOMES' AUTOMATIC EXPANSION GEAR.

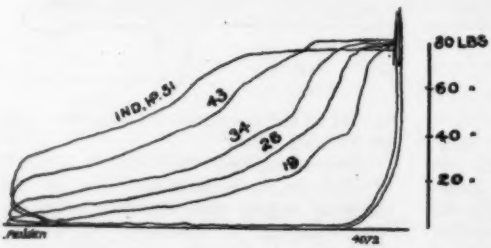


FIG. 36.—DIAGRAMS TAKEN FROM A 10-H.P. ENGINE FITTED WITH MESSRS. RANSOMES' AUTOMATIC EXPANSION GEAR.

bearings are attached to the cylinder by means of a stay, which is filled with steam so as to expand and contract in unison with the boiler. Fig. 45 shows a section of the stay, which consists of a wrought-iron tube, screwed at one end into a boss cast on the cylinder communicating with the steam jacket, and attached at the other by a sleeve and collars to the crank-shaft bracket. Steam passes through the stay from the jacket to the boiler by the small circulating pipe, causing it to expand simultaneously with the boiler and to form a tie to the bearing, preventing vibration and taking off the strain from the holding-down bolts. The engine is fitted with ordinary governors actuating a throttle-valve. Bored guides are provided in the place of slide-bars; the guide is supported by a small plate-bracket. The pump is placed vertically; a portion of the exhaust steam is conducted to the return pipe in the usual manner for heating the feed-water. Fig. 47 shows the end-view of the above engine; the cylinder seating and the crank-shaft brackets are seen. The fire-box front is flanged to a large radius, so that the mud-holes can be placed in the corners.

The seatings are of steel, riveted to the boiler, and planed. Not any of the bolts which secure the engine-parts pass into the steam space; the details can be mounted or dismounted with ease; and the possibility of leaky steam-joints is avoided. Fig. 46 shows the automatic expansion gear attached to any of Messrs. Ruston's engines when required. The action is understood.

Messrs. E., R., & F. Turner, of Ipswich, manufacture portable engines possessing some interesting features. The boiler is of the flush-top type, lagged from end to end. The crank-shaft bearings are made in three parts, with cottar adjustment for taking up the wear; they are carried on steel-plate brackets, which are bolted to angle-iron strips riveted to the boiler; the brackets are slightly flexible, and connected to the cylinder on each side by flat-iron

stays, so there is no strain on the plates of the boiler caused by the working of the engine. Every engine is fitted with the well-known Turner-Hartnell automatic expansion governor, which is keyed to the crank-shaft, and has direct control of the admission valve. It regulates the steam supply to the cylinder in exact proportion to the work to be done. There is no strap, gear, or complication of any kind, therefore little risk of accident.

Fig. 48 represents Messrs. Turner's feed-pump and water-heating apparatus. A pipe is led from the exhaust to the pump overflow pipe, and the exhaust steam thus comes in contact with the water returning to the tank, and heats it to a high temperature, thus effecting a saving of fuel.

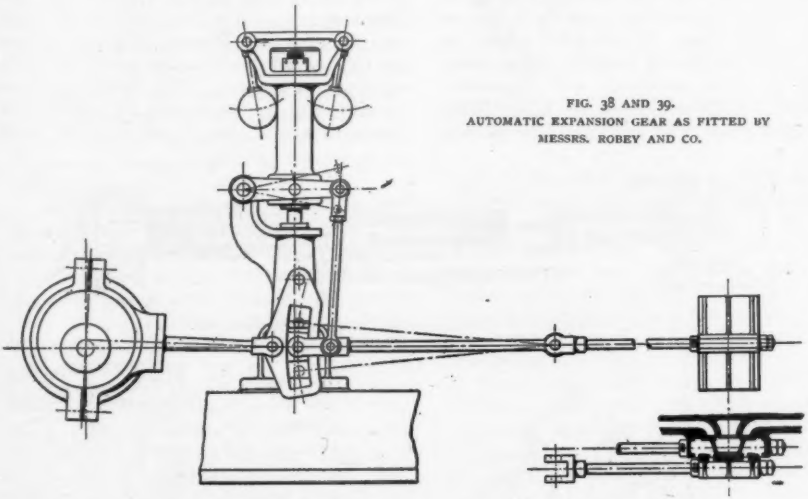


FIG. 38 AND 39.
AUTOMATIC EXPANSION GEAR AS FITTED BY MESSRS. ROBEY AND CO.

We may give expression to some thoughts which have suggested themselves during the writing of this article.

1.—It is self-evident that the shaft-governor will become more extensively used, both for controlling the speed of engines when fitted with one slide-valve, or for actuating the cut-off valve when two slide-valves are used. The shaft-governor is a safer, simpler, and a better apparatus for controlling portable engines than any other form of governor. A governor acting on the eccentric for altering the speed and power of engines, is a more efficient method of doing the work than by using a throttle-valve controlled by an ordinary governor, driven by a belt which is liable to slip, or fly off, just when the governor is most needed to act promptly.

Messrs. E., R., & F. Turner have used a shaft-governor for years. Messrs. R. Garrett & Sons have recently fitted the Turner-Hartnell form of governor to some types of their engines. Messrs. Riches & Watts also fit their compound engines in this way. Messrs. Robinson & Auden also introduced a patented shaft-governor which appears to be practically faultless. The objectionable features of other shaft-governors are discarded in the latest form of the Robinson type; for particulars of this governor, see FEILDEN'S MAGAZINE for February, 1900.

2.—It has often occurred to us that the method of heating the feed-water by a pipe led from the exhaust, is very objectionable for the following reasons:—

It is a well-known fact that if oil is allowed to enter the boiler, it will often cause overheating of the fire-box. The

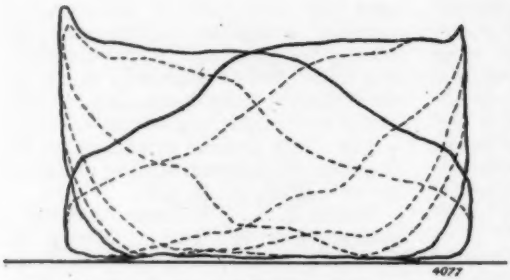


FIG. 43.—DIAGRAM TAKEN FROM ENGINE FITTED WITH ROBINSON'S PATENT GOVERNOR.

grease mixes with the muddy deposit and prevents the water from coming in contact with a hot plate. If this takes place the top of the fire-box is likely to come down, this at times occurring with disastrous results. Such accidents are more likely to take place with high-pressure boilers, and where indifferent oil is used for lubricating the piston and slide-valve. It is a pleasing fact to find that closed feed-water heaters are coming into more general use. Messrs. Brown & May have for many years used a form of water-heater which prevents the cylinder grease from coming down into the feed-water tank. Messrs. Marshall, Sons & Co. supply a water-tank and a copper coil with their compound portable engines, so as to heat the feed-water without allowing the steam from the exhaust to mix with the feed for the boiler. At the Smithfield Show, 1899, we noticed that Messrs. Ruston, Proctor & Co. used a closed water-heater on their compound engine. The following illustration, Fig. 49, represents a good form of water-heater of the closed type, as used

FIG. 45.—SECTION OF MESSRS. RUSTON, PROCTOR'S EXPANDING STAY.

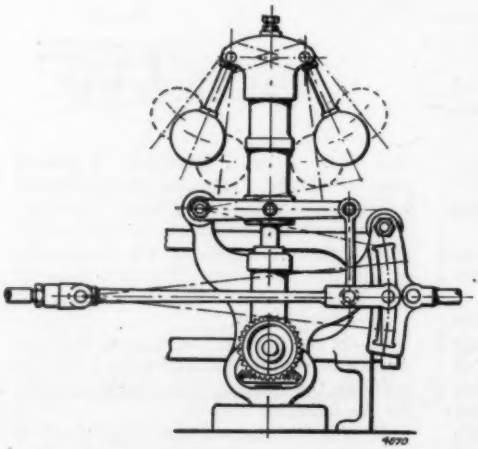


FIG. 46.—AUTOMATIC EXPANSION GEAR AS FITTED BY MESSRS. RUSTON, PROCTOR AND CO.

for years by Messrs. Wallis & Stevens, of Basingstoke, which answers the purpose well. The exhaust steam passes through the apparatus, entering by the pipe *A*, and making its exit by the opening *B*. The feed-water passes into the pipe *C*, and traverses through the tubes in the opposite direction to the steam, so that the hottest water comes in contact with the hottest steam, and enters the boiler at a high temperature through the pipe *D*. The tubes through which the water passes are partially filled by rods, so that a thin annular ring of water is exposed to the heating action of the steam.

3.—Steel seats for the cylinder, and steel-plate crank-shaft brackets are coming into favour; in some instances steel blocks are riveted

to the boiler shell for mounting other details on; for instance, in Messrs. Marshall's compound engine the brass connection between the boiler and cylinder is mounted on a separate riveted fixing. Messrs. Garrett's steel-plate saddle is simplicity itself. Steel seatings riveted to the boiler-shell for the details to rest on, are far superior to bolted connections, which have not yet died out.

4.—Spring balance safety-valves are giving place to spring-weighted valves of the Ramsbottom type; the former are liable to be tampered with, and such tampering has caused disastrous results.

5.—Bored guides are also coming into favour. Their advantages are:—Fewer details to require adjustment; the cylindrical guide is cast with the front cylinder cover; it is bored and faced at one setting; this ensures perfect alignment with the centre line of the cylinder.

6.—It will be noticed that flush-top boilers are being adopted by several of the leading makers.

7.—At one time the stop-valve and throttle-valve were arranged inside the cylinder shell casting; some years afterwards these valves were placed in a separate box by some makers; and now it will be noticed the old plan is being revived, and the stop-valve, throttle-valve, and safety-valves are all arranged in connection with the cylinder shell.

In concluding this article, we cannot omit referring to the stays between the cylinders and the crank-shaft brackets of most of the portable engines. In many instances these stays are not needed, and might be omitted with advantage. They were introduced some years ago by a firm who made their crank-shaft brackets of a flexible type. The stays in this instance were absolutely needed to act as a tie for the plate-iron brackets; the stay resisted the pull and thrust of the engine, and prevented these strains from being imparted to the brackets, which were unable to bear them. At the same time other makers introduced stays on their strong engines under entirely different conditions. The cylinders, boilers, and brackets were

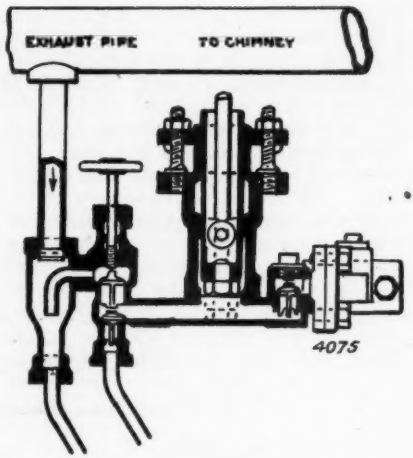


FIG. 48.—MESSRS. E., R. AND F. TURNER'S FEED-PUMP AND WATER-HEATING APPARATUS.

sufficiently stiff to bear the racking strains without injury, and no good reason could be given for their adoption of stays. It is quite true that the boiler pressures were creeping up; and the boilers made by some firms, having raised firebox shells, were somewhat fragile in the saddle plate; the engine-stays in such cases prevented the boiler tops from whipping.*

But in most modern portable engines, flush-top boilers are used which are of the strongest construction, any weakness of design has been eliminated; the cylinders and wrought-iron crank-shaft brackets are perfectly rigid, and require no stay whatever. Moreover, we are told that the stays

* On this point we may remark that a portable engine of one firm was being subjected to some heavy brake-trials, when it was found that the saddle-plate thwarts moved visibly, owing to the heavy racking strains. Some tee-iron stays were riveted inside the boiler, between the barrel and the firebox arch plate, which prevented the vibration.

FIG. 49.—MESSRS. WALLIS AND STEVENS' CLOSED TYPE WATER-HEATER.

are used so as to maintain the cylinder and crank-shaft centres the same distance apart, independently of the expansion of the boiler under steam pressure, so that the slide-valve setting and the piston clearances are not altered by the boiler's varying length. But one firm does not use a stay for this purpose: it is made hollow and heated by steam, so as to cause it to expand and contract with the boiler. See Fig. 45.

Before we leave this subject it may not be amiss to point out that the portable engine is a purely British production. No other country can manufacture such examples as have been depicted in this article. The engines made by Continental and American firms present to our eyes a somewhat grotesque appearance. The engines illustrated are not only good ones to look at, but they are good ones to go.

W. Fletcher.

NOTE.—*Figs.* 32, 37, 40, 42, 44 *and* 47 *appeared on pages* 47, 49 *and* 51 *in the previous issue.*

An Interesting Operation in Bridge Reconstruction.

By a CORRESPONDENT.

THE following account describes an interesting and unique series of operations involved in the conversion of a continuous plate-girder bridge of five spans, into a cantilever structure. The bridge in question crosses the estuary of the river Canche at Etaples, France, and the arrangement of its spans is illustrated by Fig. 1. The old structure consisted of two parts—one of timber 284 ft. long, and the other of iron 326 ft. 6 in. long. The latter portion, as indicated in Fig. 1, was divided into five spans of about 65 ft. each, over which the girders were continuous, and it was this portion of the structure which was converted into a cantilever bridge.

The necessity for executing the work with the strictest economy, without interrupting traffic and without the employment of a temporary structure led M. Marion, the engineer-in-chief, to adopt the following unique method for effecting the alteration. The main girders of the bridge are of the parallel plate-web type, 3 ft. 3 ins. in depth, and 16 ft. 3 ins. centre to centre, the carriage way being supported by a timber platform carried on cross beams spaced at 4 ft. 9 ins. The calculations for the original structure had been made in a somewhat rough and ready manner, without having due regard to the effect of the continuity of the girders, and the loads provided for were much less than those obtaining at the present time. In addition, the distribution of the stresses in the structure were found to be considerably modified by reason of very unequal settlements of the different piers, which rendered the effective strengthening of the bridge an urgent matter.

The liability of further subsidence in the piers rendered desirable the breaking of the continuity of the girders so as to avoid the abnormal stresses due to a recurrence of this contingency. Moreover, the maintenance of the continuity of the spans would have necessitated reinforcing the flanges to enable the girders to safely carry the existing loads, whilst the addition of extra flange-plates would have been both expensive and difficult of execution on the under side of the girders.

Severing the girders immediately over the three intermediate piers would have avoided these objections; but this solution, besides necessitating duplicating the bearings on each pier—a difficult matter on account of their small width of only 4 ft. 3 ins.—was also open to the objection of badly utilising the material of the old structure, since it annulled the bending moment at those points where the girders were already provided with a liberal sectional area and caused very little stress in the heavy parts of the flanges immediately adjacent to the piers. It was therefore necessary to adopt some method by which the stresses in the girders should be practically constant and independent of any future subsidence of the piers, and which should utilise to the best possible advantage the large sectional area of the old girders near the piers. It was therefore decided to convert the bridge into a cantilever structure.

The girders have consequently been severed at a certain distance from the piers, as indicated in Fig. 1. The new points of support are provided with articulations by which the independent spans thus created rest on the overhanging ends of the unaltered spans. The reduction in length of the severed spans between the articulations diminishes the moments and consequently the necessity for strengthening the girders, which would have militated against economy. The theoretical

location of the points of articulation was easily deduced by the condition of assuring the best utilisation of the sectional area

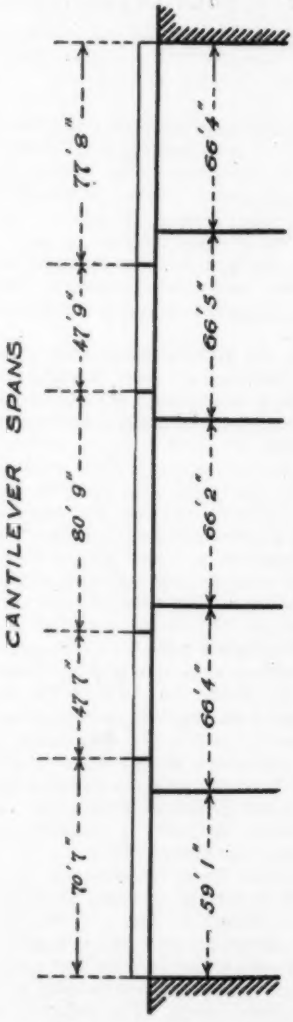


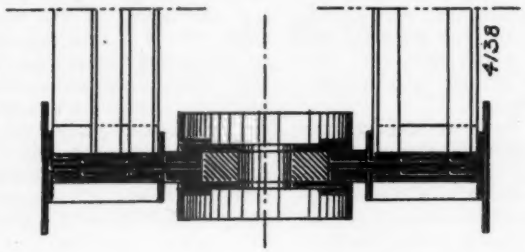
FIG. 1.—SHOWING OLD AND NEW ARRANGEMENT OF SPANS.

massed at the original points of support. They were fixed in such a manner that the bending moment, due to the combined weights of the overhanging end and of the semi-supported span, was equal to the moment of resistance of the section over the pier. It was found impossible to adopt the exact positions indicated by the calculation, as the articulations were of necessity placed in the nearest panels of the web left free between the existing cross-girders and their stiffeners, which accounts for the slight difference in length of the overhanging arms.

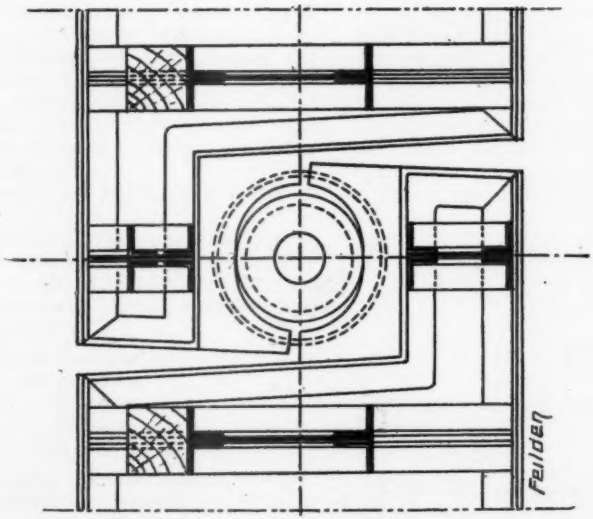
The detail of the articulations is shown in Figs. 2 and 3, the former being a longitudinal and the latter a transverse section through the joint. A hollow steel disc, $2\frac{3}{8}$ ins. thick and $11\frac{3}{16}$ ins. outside diameter, constitutes the pin. Its horizontal axis is perpendicular to and at the centre of the web of the girder. A slightly elliptical hole was cut in the web, having a vertical diameter of $11\frac{3}{16}$ ins., being equal to that of the pin, and horizontal diameter of $12\frac{3}{4}$ ins. for allowing a little free play on deflection and expansion taking place. The web being barely $\frac{3}{8}$ in. thick, and therefore possessing insufficient bearing area, is reinforced on each side by steel plates 1 in. thick cut to the same template as the hole. The combined thickness of web and reinforcing plates being $2\frac{3}{8}$ ins., renders them flush with the faces of the steel disc. These pieces being fixed, it simply remained to cut through the web and flanges so as to break the continuity of the girder and bring the articulation into play. The shape of the cuts is clearly shown in Fig. 2. The edges of the web thus severed are strengthened by $2\frac{3}{4}$ by $2\frac{3}{4}$ by $\frac{3}{8}$ ins. angles on each side, bent to the same outline as the cut.

The pin is prevented from moving laterally by two annular flanges attached to it by six bolts. These flanges are formed of two circular steel plates $\frac{9}{16}$ in. thick and 16 ins. diameter (the pin being $11\frac{3}{16}$ ins. diameter), stiffened by circular angles $2\frac{3}{4}$ by $2\frac{3}{4}$ by $\frac{3}{8}$ ins. In Fig. 2 the interior flange is removed. Both pin and flanges are pierced by a hole 4 ins. in diameter, which gives the joint a lighter appearance and assists the alignment of the joints on opposite sides of the bridge. Since the truncated ends of the girder webs above and below the pin are reduced to half their original depth, their section

was insufficient for safely resisting the shearing force, and they were therefore augmented by riveting on additional $\frac{3}{8}$-in. plates. Finally, to maintain the correct $\frac{3}{8}$ ins. The upper one has its top angles lowered to suit the convenience of the joint in the platform provided for assuring the complete independence of the adjacent



TRANSVERSE SECTION THROUGH JOINT.



LONGITUDINAL SECTION THROUGH JOINT.

FIGS. 2 AND 3.—DETAILS OF THE ARTICULATIONS.

transverse distance between the main girders, two additional cross-beams were placed above and below the articulation. These cross-beams are made up of a web $9\frac{9}{16}$ by $\frac{3}{8}$ ins. and four angles $2\frac{1}{4}$ by $2\frac{1}{4}$ by

spans. The parapets also break joint over the articulations.

The order of the operations in making the articulations was as follows: The additional cross-beams and the stiffening

plates of the upper and lower parts of the web were first fitted, after which the elliptical openings for receiving the pins were cut. Into these the pins were introduced after having riveted to the web the 1-in. bearing-plates. Lastly, the flanges for preventing lateral displacement were bolted to the pins. It then only remained to sever the girders, which was done by commencing at the pin and working outwards towards the flanges.

The work was executed without experiencing any special difficulty and without interrupting the traffic. For several of the articulations the labour of severing the flanges was materially reduced by the tendency of the rupture to extend itself as the web became weakened and the freedom of the pin-joint came into action. The remainder of the work included the addition of new cross-girders and wind-bracing; the construction of new footways, carried by brackets, replacing the timber platform; and the raising of the whole structure about 16 ins. The old timber bridge adjoining was replaced by four independent spans supported by screw piles, the junction between the new and the altered structures being made by a hinged joint of the type above described. The total cost of the reconstruction, including the new bridge, was £7,100, the contractors being Messrs. Kessler & Co., of Argenteuil.

J. H.

Notes on Beams.

Bending Moments and Moments of Resistance.

By H. G. TICEHURST, M.I.Mech.E

❀ ❀ ❀

Fig. 1 shows a rectangular beam supported at both ends and uniformly loaded. The greatest bending moment in this instance will be at centre of span, and equals $\frac{WL}{8}$. For by taking moments about centre, we get :—

$$\frac{W}{2} \times \frac{L}{2} - \frac{W}{2} \times \frac{L}{4} = \frac{WL}{8}.$$

The bending moment dies off each way towards the points of support, where it is zero (see curve, Fig. 1). So, obviously, at the centre of the beam, the material composing it is stressed to a greater extent than at any other point. Now, this greatest bending moment has to be resisted by the "moment of resistance" with reference to the neutral axis; that is, the material (*a*) above neutral axis must resist crushing, and the material (*b*) below neutral axis must resist extension, and the one with the lowest moment of resistance should be taken into account.

The moment of resistance is found as follows :—

Suppose Fig. 2 to be a cross section of beam shown in Fig. 1. This cross section may be considered to be made up of an infinite number of laminæ parallel to the neutral axis XX.

Let *ll* be one of these laminæ.
" t " its thickness.
" b " " breadth,
" x " " distance from XX.
" f " stress on lamina per unit.

Then the total stress on lamina $ll = fbt$, and its moment with respect to neutral axis

$$= fbtx \quad \ldots \quad \ldots \quad (1).$$

If d_1 = distance of extreme fibres at *ab* from XX,
" d = distance of extreme fibres at *cd* from XX,
and f_1 = compressive unit stress at *ab*,
" f_2 = tensile " " at *cd*,
then, $f : f_1 :: x : d_1$,

$$\text{or, } f = \frac{f_1 \times x}{d_1} \text{ (compressive)};$$

likewise, $f : f_2 :: x : d_2$,

$$\text{or, } f = \frac{f_2 \times x}{d_2} \text{ (tensile)}.$$

Substituting these values of f in equation (1), we get moment of stress on lamina *ll*

$$= \frac{f_1}{d_1} btx^2 \text{ (compressive)} \quad \ldots \quad (2),$$

$$\text{and } \frac{f_2}{d_2} btx^2 \text{ (tensile)} \ldots \quad \ldots \quad (3).$$

If the tensile strength of material is equal to the compressive strength, then (2) will equal (3), and the neutral axis will pass through the centre; but, if not, the weakest must always be dealt with. As we assumed the cross section made up of an infinite number of laminæ, such as *ll*, we must sum up the moments of stress for an infinite number of laminæ, or, in the notation of the calculus :—

Total stress on half section

$$= \frac{f_1}{d_1} \int_0^{\frac{D}{2}} bx^2 dx \text{ (compressive)};$$

$$\text{or, } \frac{f_2}{d_2} \int_0^{\frac{D}{2}} bx^2 dx \text{ (tensile)}.$$

If tensile strength equals compressive strength, then

$$\text{Total stress on half section} = \frac{f}{d} \int_0^{\frac{D}{2}} bx^2 dx$$

$$= \frac{f}{d} \frac{bx^3}{3}$$

and as $x = \frac{D}{2}$, where D = height or depth of beam,

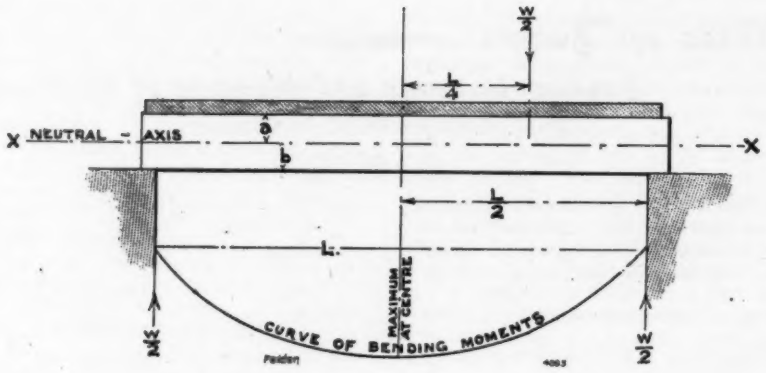


FIG. 1

$$= \frac{f}{d} \times \frac{bD^3}{24} \quad \ldots \quad (4).$$

This is the moment of resistance for half the section. The moment of resistance for the whole cross section is:—

$$\frac{f}{d} \frac{bD^3}{12} \quad \ldots \quad \ldots \quad (5)$$

Now, the quantity $\frac{bD^3}{12}$ is known as the moment of inertia of the section, and is usually denoted by I. So that

Moment of resistance of *any* section can be expressed

$$\frac{f}{d} I \quad \ldots \quad \ldots \quad (6)$$

where f equals stress on fibres at a distance d from neutral axis.

In all instances the bending moment must equal the moment of resistance.

In the case of a uniformly loaded beam, supported at both ends, as in Fig. 1,

$$\frac{WL}{8} = \frac{f}{d} I$$

$$W = \frac{8f}{dL} I \quad \ldots \quad (7).$$

Values of f must be taken to suit in-

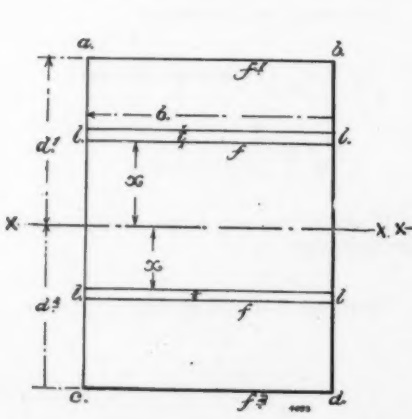


FIG. 2.

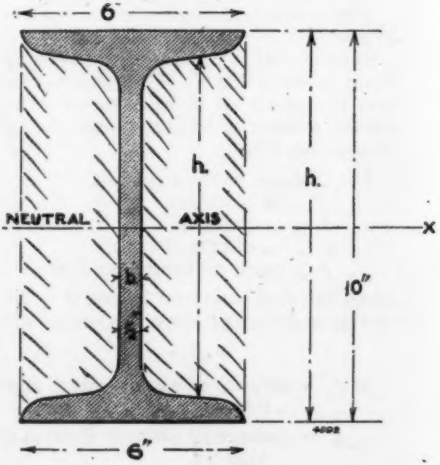


FIG. 3.

dividual cases. For instance, consider a wrought-iron rectangular beam, 2 ins. wide by 4 ins. deep and 24 ins. long, and suppose the material is not to be stressed more than 6 tons per square inch, the load equally distributed on beam to fulfil this condition

$$= W = \frac{8f}{dL} I$$

$$W = \frac{8 \times 6}{2 \times 24} I$$

and as $I = \frac{bD^3}{12}$

$$W = \frac{8 \times 6 \times 2 \times 64}{2 \times 24 \times 12} = 10{\cdot}6 \text{ tons.}$$

To apply the foregoing principles to an H girder of an ordinary size (Fig. 3) the moment of inertia with respect to XX is equal to the moment of inertia of the rectangle formed by the depth (L) and side (b) minus the rectangle compounded of the open hatched area.

$$\text{Thus, } I = \frac{bD^3}{12} - \frac{(b - b_1) D_1^3}{12}$$

$$= \frac{1}{12}\left\{bD^3 - (b - b_1) D_1^3\right\} \quad (8).$$

where b = side,
b_1 = width of web,
D = outside length,
D_1 = inside length between flanges.

The moment of resistance will be (see 6)

$$\frac{f}{d} I$$

and taking a skin stress of 8 tons per square inch,

Moment of resistance

$$= \frac{8}{5} \times \frac{1}{12}\left\{6 \times 1000 - (6 - {\cdot}5)\, 615\right\}$$

$$= \frac{8}{60} (6000 - 3375)$$

$$= \frac{8}{60} \times 2625$$

$$= 350 \text{ inch tons.}$$

This must be equated to the bending moment, and this latter will, of course, depend upon the manner the girder is loaded. If uniformly loaded and supported at both ends,

Bending moment $= \frac{WL}{8}$, and taking L as 12 ins. $\frac{WL}{8} = 350$

$$W = \frac{350 \times 8}{12} = 233 \text{ tons.}$$

This being the safe load for 1 ft. span, the load for any other span can be obtained by dividing 233 by the span in feet; thus, for 10-ft. span, the load is 23·3 tons, and this load will not stress the metal more than 8 tons per square inch, or one-quarter the breaking load, if of steel.

H. S. Nicholson

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Diagonal Engines for Paddle Steamers.

By GEO. HALLIDAY, Wh. Sch.

(Continued from page 64.)

THE largest and most powerful paddle-steamers in the world, are those employed on the cross-channel service. Those diagonal engines which develop the power in the *Marie Henriette*, on the Ostend-Dover service, which we are about to describe, were built by the Société Anonyme John Cockerill, in their works at Seraing, near Liége.

The engines, which are of the compound diagonal, surface condensing, side-paddle type, are illustrated in Fig. 7. There are two inclined cylinders of 60-ins. and 108-ins. diameter respectively, with their centre lines parallel to each other; the stroke is common, and 84 ins. in length. The stools for the cylinders are of triangular shape and with their upper faces parallel to the centre lines of the cylinders. These are strongly constructed, and have triangular webs between the two inclined flanges, and are bolted to the foundations of the engines. The bed-frame of the engine is of girder shape and is in two parts, one piece being bolted to the cylinder stool, and the other to the crank-shaft frame, the two bed-plates being joined together by bolting to the flanges formed on them for that purpose. As seen from the photograph, the crank-shaft framing consists of strong castings bolted to the bed framing. Standards tie the framing at the bearings with the cylinders, and these standards are formed in such a way that they serve as guides for the piston-rod crossheads. In order that the framing may be further strengthened, it is braced together transversely. The shape of the cross-section of the standards on which the crosshead slides is in the form of an I, while the other parts are of circular section.

The crank-shaft is of forged steel, and made hollow in the bolts and crank pins; it being uniformly throughout 19$\frac{1}{16}$ ins. in diameter, the main bearings of the shaft are 19$\frac{1}{16}$ ins. in length, and the crank pins 23$\frac{5}{8}$ ins. in length. At each end of the shaft there is a strong flanged coupling to which the paddle-shaft flange is bolted. These paddle-shafts are also made hollow and of forged steel, and of the same diameter as the crank-shaft. The outside supports of the paddle-shafts are of cast steel, fitted with a cast-steel bearing in which the shaft rests. This steel bearing is 4 ft. 3$\frac{3}{4}$ ins. long, and it is lined with white metal. The cover is hollow and simply acts as a keep, for it does not touch the shaft.

The tops of the cylinders are cast along with the body, but these tops have manhole covers which are cast with the stuffing-box for the piston-rods. The hole in the cylinder, when this manhole door has been unfastened and pulled along the piston-rod is sufficiently large to allow a man to get into the cylinder. On the top of the cylinder there is an escape-valve 5$\frac{1}{8}$ ins. in diameter, loaded with a spring, and another placed on the manhole door. The pistons are conical in shape to give them strength. They are of cast steel and have a single broad cast-iron ring with spring of the ordinary type behind it on the upper part, but not on the bottom. The weight of the piston is supported with a packing piece, and on the top of the ring is the tongue. The piston-rods are of forged steel, and 10$\frac{1}{4}$ ins. in diameter. The stuffing-boxes are of the metallic-packing type. The piston-rods crossheads are also of forged steel, and have two journals. The slippers on the guide-bars are of cast-iron, lined with white metal. To ensure that the slippers shall only be pressed in the centre, and also that they may not be subjected to the fixture of the crosshead, the latter is attached to it in a peculiar way. The two ends of the crosshead are bolted up to U-shaped pieces of forged steel, the branches of the U being supported on the slipper by set bolts. The pressure of the

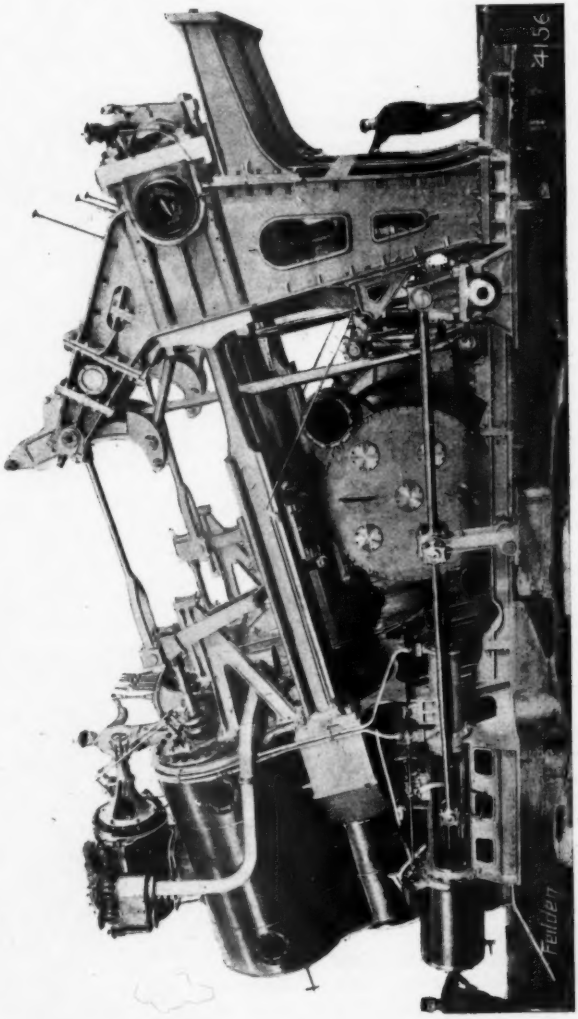


FIG. 7.—8300 I.H.P. DIAGONAL SIDE-WHEEL ENGINES OF THE P.S. "MARIE HENRIETTE."

crosshead is thus brought on the middle of the slipper and distributed equally over the surface of the guide.

The high-pressure cylinder is fitted with a piston-valve, which moves in a hard cast-iron chamber, while the low-pressure cylinder has two flat double-ported valves, which work on hard cast-iron faces. The two valves work together side by side, and as they have smaller faces have less deformation under the effect of heat than a single large valve would have.

The valve-gearing is of the Walscheart type, and was brought out simultaneously by Mr. Walter Brock, of Dumbarton, and by M. Hensinger de Waldeck, in Germany. A single eccentric gives the motion to the valve. It first moves a link, which oscillates on a fixed centre. This link then acts on another, which is fixed to a movable centre one end of which is moved by the crosshead. One motion gives the valve the lead the other the travel. Steam and hydraulic reversing gear effect the linking up, and these are worked from the engineer's platform. There is also a hand-force pump for doing this work when there is no steam to work with.

The condenser is of a single piece, cylindrical and formed of steel plates with gun-metal covers. It is separate from the engines and placed thwartships, and has a cooling surface of 10,226 square feet. The tubes have an external diameter of $\frac{3}{4}$-in., and are of gun-metal, as also are the tube plates. The joints between the tubes and plates are of the stuffing-box form. The two air-pumps are worked by bell-crank levers from the main crossheads. The bodies of the pumps are of bronze and the covers are cast-iron. They are $37\frac{3}{4}$ ins. in diameter, and they have 2 ft. $1\frac{1}{2}$ in. stroke. The pistons of the pumps are of gun-metal, as are the valve seats. The circular-valves are of rubber.

The paddle-wheels of the *Marie Henriette* are 22 ft. 4 ins. external diameter, and each wheel is fitted with nine feathering curved floats, 15 ft. in length and 4 ft. 4 ins. in breadth.

Eight cylindrical boilers of the return tube type supply the steam. The forced draught is of the closed stokehold type. The total heating surface is 14,100 sq. ft., and the total grate area 465 sq. ft. The working pressure is $117\frac{1}{2}$ lbs. The boilers are single-ended, are 13 ft. 4 ins. in diameter, and are 10 ft. 3 ins. long. Three Fox's furnaces are fitted in each boiler, and the diameter of each is 3 ft. $2\frac{3}{4}$ ins.

The paddle steamer in which these engines are fitted is 340 ft. long, 38 ft. broad, and 15 ft. depth of hold, measuring from the main deck. The hull is of steel, the machinery rooms take up 120 ft. of the length, there are seven coal bunkers with a capacity of 100 tons. The trials of the vessel were made on the Clyde, and she made the voyage from Antwerp in 56 hours. The mean draught during the trials was 8 ft. $11\frac{1}{2}$ ins. During the four runs over the 13·666 nautical miles between the loch and the Cumbrae Lights, two with and two against the tide, the mean speed made was 22·2 knots per hour, the mean revolutions 52·89, and the i.h.p. 8134. The air-pressure in the stokeholds was $1\frac{3}{8}$ in.

Messrs. Rankin and Blackmore, of Greenock, have been working on different lines. They have devoted themselves to the development of the diagonal side-paddle engine, and it has resulted in an engine of triple-expansion type in four cylinders. There are two cranks, and the cylinders are arranged in pairs placed tandem. The firm also has arranged to construct the engines on the disconnective principle, so that one set may work alone. It was their diagonal compound disconnective type which they fitted in the *Mount Etna*, a tug steamer owned by the Queenstown Towing Company, and built by Mr. Robert Chambers, jun., Dumbarton. Her measurements are — 145 ft. in length, 21 ft. 6 ins. beam, and 13 ft. 6 ins. in depth. The engines are two in number (Fig. 8), each working on its own crank, and they are placed diagonally side by side. The dimensions of the cylinders are — high-pressure 25 ins., low-pressure 48 ins., and they have a common stroke of 5 ft. The cylinders are supported on a diagonally shaped stool of cast-iron, to which they are firmly bolted, it, in turn, being bolted

to the framing of the ship. The cylinders have brackets cast on them, and these are machined to take the ends of the rectangular-shaped cast-iron side frames of the engine. These side frames have a slotted part along their sides, which is machined and serves as the guide for the slide blocks of the piston crossheads. The ends of the frames are so shaped and fitted as to carry the bearings for the crank-shaft.

The cast-iron surface-condenser is placed under the crossheads and framing, immediately in front of the cylinder stool, and the pumps are immediately in front of the condenser, and are worked from the crossheads. The surface-condenser and pumps are carried and bolted to the same strong cast-iron base, which again is strongly bolted to the cylinder stools. The side framing of the engines is supported by strong columns fitted to the frame under the shaft and bolted to the pump-base. It will also be noticed that there is a large receiver for the steam exhausting from the high-pressure cylinder between the two cylinders.

When both engines are worked together, the steam passes first into the high-pressure cylinder through an expansion-valve. This valve admits of a variable expansion of the steam in the cylinder ranging from one quarter to seven-eighths of the stroke to suit the power required from the engines at the time. When the steam has done its work in the high-pressure cylinder it exhausts into the intermediate receiver, and from there into the low-pressure cylinder through an expansion-valve, which cuts off at variable points to suit the power required as in the high-pressure cylinder in the usual way. From the low-pressure cylinder it exhausts into the surface-condenser under the framing. When the two engines are to be worked separately, the gear for disconnecting the shafts of the two wheels is set so as to disconnect. If it is to be the high-pressure engine

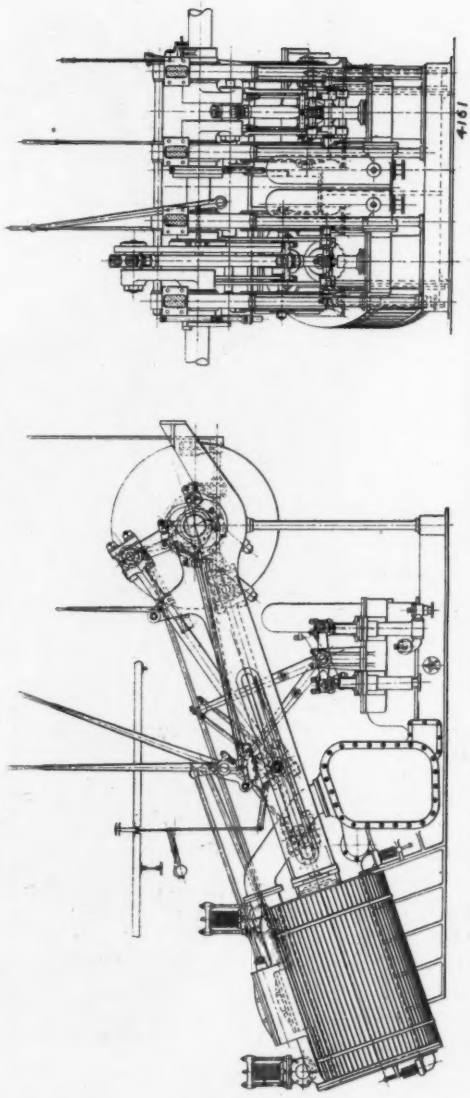


FIG. 8.—ARRANGEMENT OF RANKIN'S PATENT TWO-CYLINDER DISCONNECTING COMPOUND ENGINES FOR P.S. "MOUNT ETNA."

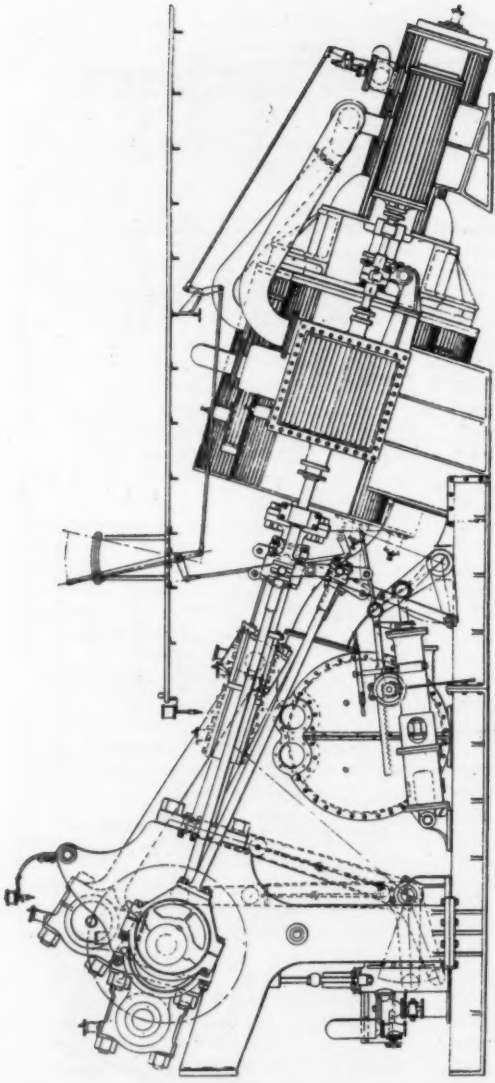


FIG. 9.—FOUR-CYLINDER DISCONNECTIVE TRIPLE-EXPANSION ENGINES OF THE P.S. "HYGEIA."

which is to work, then valves are arranged so as to allow the steam to exhaust into the condenser or atmosphere.

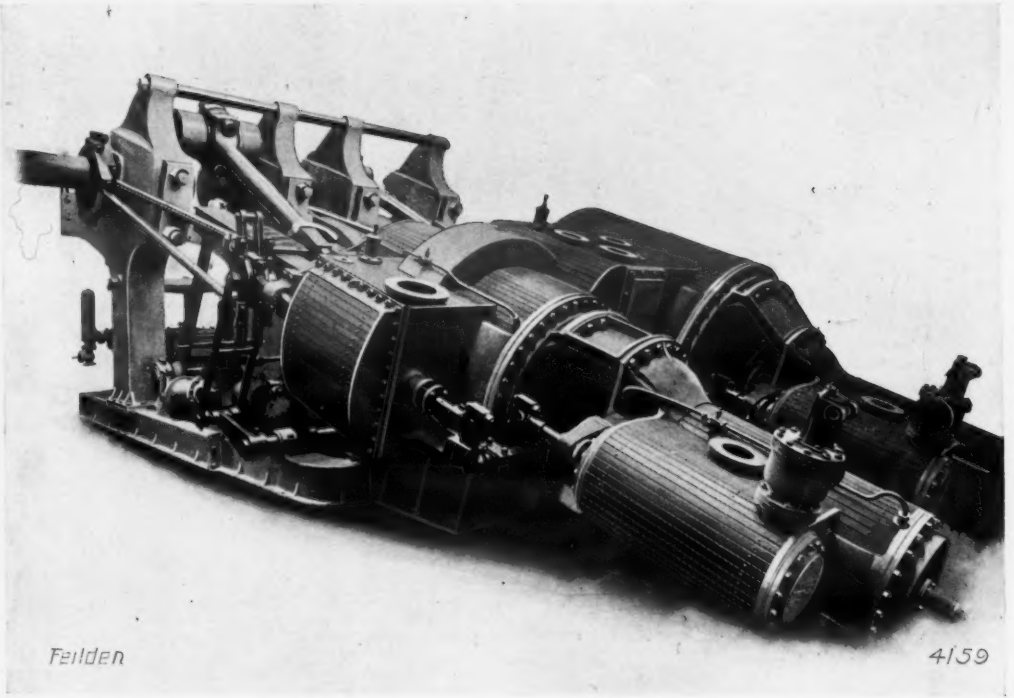
When the low-pressure paddle-shaft is to be worked alone, steam is admitted directly to the low-pressure cylinder through a reducing-valve, whence it exhausts into the condenser. Thus, when the engines are working together, there is the advantage of the compound expansion, and the economy in coal consumption following that. But this advantage does not interfere with the separate working of the paddles, which is so often required in manipulating a tug boat in harbour or in confined situations.

On her trial trip, the *Mount Etna* made 12½ miles per hour when the engines were making 37 revolutions per minute and indicating 500 horse-power.

The next development of the Rankin type of disconnective expansion engines was on the triple-expansion principle. It was ultimately applied to the set of diagonal engines for the paddle-steamers *Hygeia* and *Marchioness of Lorne*, but was first tried in the engines of the twin-screw steamer *Arabian*.

The engines of the *Arabian* are of the inverted cylinder tandem type. The *Arabian* was a twin-screw steamer built for the coasting trade of the West of Scotland. Her dimensions are:—126 ft. in length, 22 ft. beam and of 9 ft. 6 ins. depth in the hold. Her builders were Messrs. Murray of Dumbarton, and she was intended to carry 240 tons on a light draught, this being necessary in trading to the Hebrides and West Highlands. The engines have four cylinders, one tandem pair for each crank. The intermediate and low-pressure cylinders are fitted one on each set of columns, and each of these cylinders has a high-pressure cylinder on the top of it. The engines are

SUP



FOUR-CYLINDER DISCONNECTIVE TRIPLE-EXPANSION ENGINES OF THE P.S. "HYGEIA."

Constructed by Messrs. RANKIN & BLACKMORE, Greenock.

See page 143.

carried on a common base which is firmly bolted to the ship's frame, and to save space the surface-condenser is fixed between the engines. The dimensions of the cylinder are—two high-pressure cylinders 9 ins. diameter, one intermediate of 18 ins. diameter, and one low-pressure of 32 ins. diameter. The intermediate cylinder with a high-pressure cylinder above it is mounted above the port crank-shaft, while the low-pressure cylinder and the other high-pressure cylinder above it is placed above the starboard crank-shaft. The stroke is common, and is 22 ins. in length. There is a receiver surrounding the intermediate cylinder, and it is divided into an upper and lower chamber. The lower chamber is connected to the high-pressure cylinder exhaust pipes, and the valve-chest of the intermediate-cylinder. The upper chamber of the receiver is in communication with exhaust from the intermediate-cylinder, and by a pipe with the valve-chest of the low-pressure cylinder. This pipe is fitted with a spring-loaded valve which opens into a pipe open to the atmosphere. There are also two pipes connecting the upper and lower chambers of the receiver, with a spring-loaded valve between them; and this valve opens and allows steam to pass from the lower to the upper chamber of the receiver when the steam in the lower chamber attains a certain pressure.

These engines may be both at work together, or each may be at work separately. The steam is distributed for the different cases as follows:—

When both engines are at work, the steam exhausts from the two high-pressure cylinders into the lower chamber of the receiver, and passes from that into the valve-chest of the intermediate-cylinder. After it has passed through the intermediate-cylinder, the steam exhausts into the upper chamber of the receiver, and from that passes into the valve-chest of the low-pressure cylinder, and after that exhausts into the surface-condenser.

Suppose the starboard engine is to be worked, the port engine being stopped by the reversing-gear. In this case the steam will exhaust into the lower part of the receiver, and when its pressure rises high enough there, will pass into the upper chamber of the receiver, and from that pass into the valve-chest of the low-pressure cylinder. When the steam has done its work in the low-pressure cylinder it exhausts into the condenser.

When the port engine is to be worked alone, the intermediate cylinder and high-pressure cylinder above that act together, and the starboard engine is stopped by the reversing gear. In this case the steam on leaving the first high-pressure cylinder passes into the lower chamber of the receiver, and from there into the valve-chest of the intermediate cylinder. When the steam has done its work in this cylinder, it will exhaust into the upper chamber of the receiver, and when its pressure rises sufficiently will exhaust into the atmosphere.

A set of engines working on the triple-expansion principle in four cylinders were fitted as diagonal engines into the side paddle-wheel steamer *Hygeia*, built by Messrs. Napier, Shanks & Bell, Messrs. Rankin & Blackmore supplying the machinery. The vessel was built for the Port Philip Bay passenger trade, her dimensions being—length 300 ft., beam 32 ft., and depth 12 ft. The engines (see general view, supplement plate, and side view Fig. 9) are of the direct-acting diagonal triple-expansion disconnective surface condensing type. The two high-pressure cylinders are each 28 ins. diameter, the intermediate cylinder 56 ins., and the low pressure 86 ins. diameter, the stroke being 66 ins. There are two cranks placed at right angles to each other, but each wheel can be worked separately or together. The intermediate cylinder, with a high-pressure cylinder behind, actuates one crank; while the low-pressure cylinder, with a high-pressure cylinder behind it, is for the other crank. The high-pressure cylinders are supported on stools, and these are firmly bolted to the ship's framing. The low-pressure and intermediate-pressure cylinders are also supported on suitable base-framing, and this is bolted to the other parts of the base-framing, thus making one solid strong cast-iron base for the engines. The shaft is supported on massive vertical cast-iron

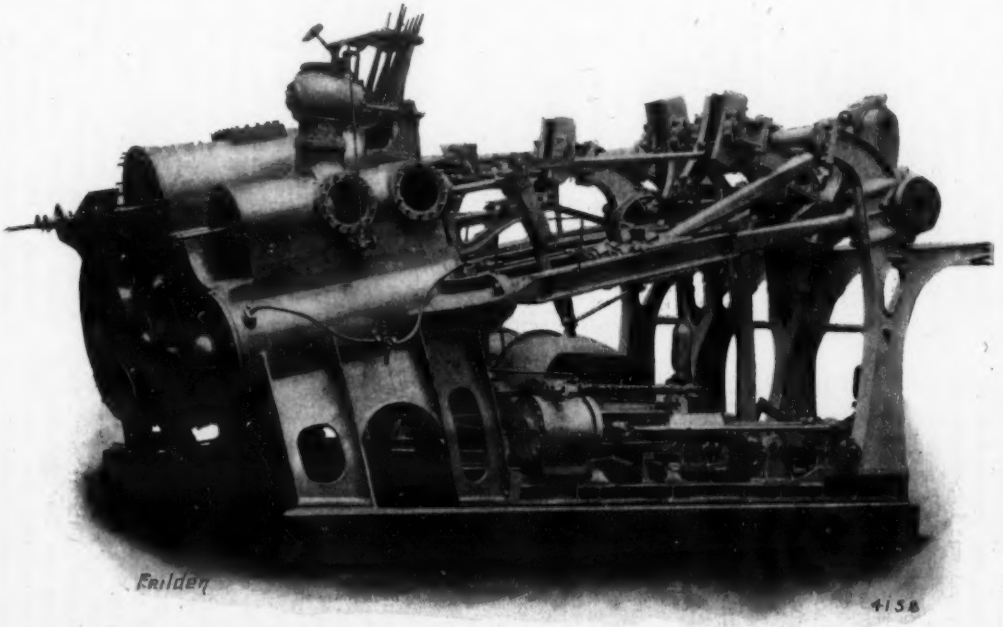


FIG. 10.—TRIPLE-EXPANSION ENGINES CONSTRUCTED BY MESSRS. DENNY AND CO., DUMBARTON, FOR THE CROSS-CHANNEL SERVICE.

frames, and these are bolted at the bottom flanges to the base frame. There are four of these strong vertical columns, and they are tied together at the top by a strong tie-rod passing through holes made in them for the purpose. There are additional ties between the cylinders and the shaft-framing. These frames, put in to take the strains existing between the cylinders and shaft, are of strong forged iron. They are bolted at one end to strong brackets cast on the cylinders, and at the other end they are attached by T-heads to the shaft frames. These wrought-iron frames serve as guides for the cross-heads, and at the wearing parts have been shaped of suitable section for that purpose.

The connection arrangement between each pair of tandem cylinders is peculiar to Rankin & Blackmore's engines.

The steam is distributed to the intermediate-pressure cylinder by means of a trick-valve, that of the low-pressure cylinder is of the double-ported type, while piston-valves are used on the high-pressure cylinders. The motion of the valves is obtained by eccentrics from the shafts through a double-bar link type of expansion gear. The link gear is worked by one of A. & R. Brown's steam and hydraulic reversing engines. As there are two high-pressure cylinders, there is no chance of the engine sticking at the dead centres, nor are starting-valves required. The engines thus can be started from any position at any time. The distribution of the steam when the engines are working together or separately, is the same as in the engines of the *Arabian*.

The two single-acting air-pumps are worked by drag-links and bell-cranks from the piston-rod crossheads. The same arrangement is made for the feed and bilge-pumps; and these all, when acting, set up a balance with the pistons, cross-heads, etc.

On the official trials on the Clyde, the *Hygeia* made an average of 22·8 miles per hour over the course.

Fig. 10 illustrates one of the fine large triple-expansion diagonal side-paddle surface-condensing engines constructed by Messrs. Denny of Dumbarton. The triple expansion is effected in three cylinders which are bolted together, the spaces between forming receivers. They are fitted with large escape-valves on top and bottom, which are held down by spiral springs. The steam is admitted to the receivers through valves, the handles actuating which being situated on the starting platform. There is a double beat valve chest fitted on the top of the high-pressure cylinder valve chest, and the gear for working this is led to the starting platform. Drain cocks are fitted to all cylinders and receivers, and the gear for working them led to the starting platform. The cylinder-cones are made with strong ribs and lagged. The pistons are of cast-steel and coned to gain the necessary strength. The joint and packing rings are of cast-iron, and Ramsbottom packing is used in all the pistons. The joint-rings are screwed into the body of the piston by iron studs, and further secured with nuts and split collars. Countersunk collars are provided for the studs under the joint-rings so that they may not slack back. The piston-rods are of steel, and are fastened to the pistons by cones and nuts. A set-pin is screwed through the nut of the piston-rod and presses into a recess in the rod. The valves for the high-pressure and intermediate cylinders are of the piston type fitted with metallic packing. Separate valve-liners are fitted and bored out in their places. The valve for the high-pressure cylinder is of the double-ported slide type, with a relief-ring fitted in the back. Murray's metallic packing is used for the piston and valve spindle glands.

The framing is of cast-steel, and is bolted to the cylinder stools, which are one with the cylinders. The shaft framing is bolted to the base framing, and strong cast-steel pieces connect the shaft framing with the cylinders. These are made of *H* section next the cross-head guides and carry them. The cross-heads are of forged steel, and are fitted with cast-steel guide-blocks with adjustable white metal slippers bolted to them They have bearings turned on them for connecting-rod brasses. The guide columns are round at the

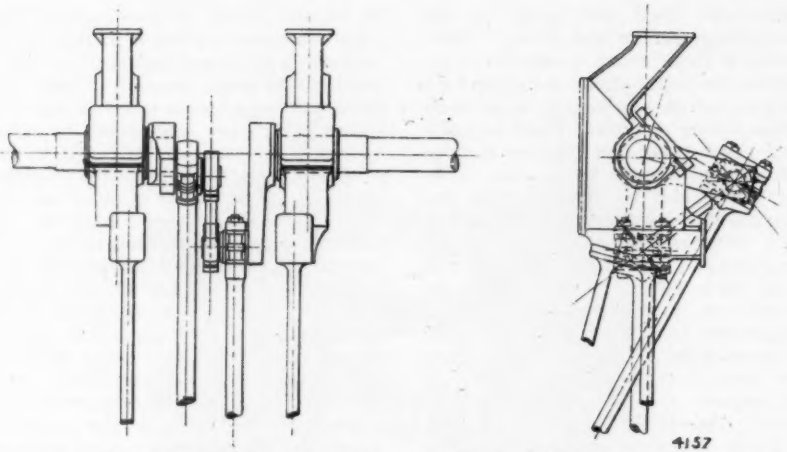


FIG. 11.—ARRANGEMENT REFERRED TO ON PAGE 60 FOR CONNECTING CRANKS BY MEANS OF A SPECIAL LINK.

necks, and are connected to the entablature by oblong couplings and bolts, which pass right through the entablature, and serve as main-bearing bolts.

The connecting-rod is of ingot steel, with double bearing on cross-heads, with binders of gun-metal and bolts of ingot steel. All the nuts are fitted with rings, guards, and set pins. The eccentrics and rods are of cast iron, and are keyed to the shaft, and have set pins sunk into keys to prevent side shift. Only one eccentric is used to each valve. The straps and rods are of steel, and these rods are fixed to the straps by T-ends with pins and to the quadrants by adjustable gun-metal bearings.

The valve gear is worked by double-barred link motions of the fixed kind, so as to keep the lead constant for all grades of expansion. The entablatures are of cast-steel, and are fitted with cast-iron main bearing bushes lined with white metal. They are stayed together at the top by a cast-steel tube, which forms a distance piece, and also a support for the quadrants.

The air-pump is worked by a lever off the low-pressure cross-head, and fastened to the engine-seating. The hot-well is cast on pump, and drains to the lower pump float-tank. The starting gear is Browns' combined steam and hand-starting type.

It should be mentioned that in engines of this type there is always a danger, when there is much stopping and starting, of the engines being started without the drain-cocks being open. Mr. Brock has arranged the starting gear so that the engines cannot be started without the drain being open.

Engines of this type fitted on the paddle steamer *Leopold II.*, of the Ostend service, do very excellent work, and easily made 22 knots an hour on trial. Those also fitted in the "Belle" steamers are great favourites with the engineers in charge of them. They are light, strong, and do their work, between London and the East Coast watering-places, on a very small coal supply.

Geo. Halliday

The Second International Tramways Exhibition.

By OUR SPECIAL COMMISSIONER.

INTRODUCTION.

THE movement in favour of the adoption of Electric Tramways and Railways, although upon us, has been a long time in arriving, considering that Messrs. Siemens exhibited a model electric railway as early as 1882, at the Crystal Palace Electrical Exhibition of that year, that Mr. Magnus Volk's electric railway on Brighton beach was opened for traffic in August of the following year, and the Blackpool electric tramway of Mr. Holroyd Smith in 1885. The first electric tramway in America appears to have been started in 1885, and the first electric tramway or railway on the Continent, a few years earlier Yet electric tramways have gone ahead by leaps and bounds, both on the Continent of Europe and in America, while we in England have stood practically still until within the last few years. Now we have got the fever very strongly. Bristol, Leeds, Glasgow, and other large towns have already been equipped with tramways run by electricity over nearly their whole municipal areas, and almost every other town of any importance, as well as many smaller towns, have either already obtained powers to lay down electric tramways, or have Bills at present before Parliament for the purpose. In addition to this, the Light Railways Act, though it has apparently been somewhat grudgingly administered by the Commissioners, has also put an entirely new field at the disposal of electrical engineers—a field whose possibilities are very wide. And this is not the whole of the matter as it stands at present. American and Continental engineers have boldly attacked the problem of working suburban and branch lines by electricity, and the proposals are getting bigger and bigger, culminating in a bold though cautious proposal by Mr. W. Langdon, the President of the Institute of Electrical Engineers, who is the electrical engineer to the Midland Railway, to run a section of the Midland main line by means of electric locomotives.*

It goes without saying that in the early days, many mistakes were made, and that in the early pioneer work many troubles arose which had not been dreamt of, and which cost the engineers who were working out the problem many anxious times, and their backers much hard cash; but the main point to be remembered is that the opportunity was given them of obtaining the necessary experience, and of working out the many details of the problem under conditions where an occasional failure did not matter, and usually was not heard of till long after, when the difficulty had been overcome; and this gave the American engineers the knowledge they required when the next stage arrived. The horse-tramway had been first established in America, and it had spread itself over the great cities on the Atlantic seaboard. It was a great improvement upon the horse-driven vehicle, running on the common road, especially with the roads of most American cities at that date. The adoption of the car running upon rails enabled two horses to pull a larger number of passengers than the vehicle running on the plain road, owing to the great reduction of friction; but at the time when the American engineers were beginning to come through their trouble with the electric tramway problem, the horse tram had fallen on bad days, it was not quick enough for the hustling

* Other important papers have also been presented by Messrs. Mordy & Jenkins to the Institute of Civil Engineers, and by Messrs. Swinburne & Cooper to the Institute of Electrical Engineers, in which electrical railway problems are very fully discussed.

American, who preferred one or other of the railways of different forms which had sprung up, and so the horse-car lines were earning nothing. Hence when it was shown that the cities out West had tramways which were fairly successful, and that the system promised economy in working and speed which would enable the tram lines, or the street railways as they are called in America, to compete with the steam lines, the principle was soon adopted by several of the leading cities on the Atlantic seaboard, such as Boston and Baltimore. Their success was immediate. Lines which had been paying no dividend for years, and which were seriously considering the advisability of winding-up, sprang into new life, and became handsomely paying concerns. And this led to the extension of the older cities, and to the provision of dwelling-houses for their workmen, by the great industrial concerns, such as the great steel companies of Pittsburgh, at some distance from the works, the residential portions being connected with the works by electric tramways which carried the workmen quickly and cheaply to and from their work. And again the experience gained with the street railways, many of which became extended over very large areas, led to the attack of the problem of running the overhead street railways by electricity, of which the Chicago South Side Elevated Railway is a noted example; and this again led to further advances, the experience gained providing sufficient data for attacking the next stronghold of steam, till now it would appear that it is only a question of time how soon steam on railways and tramways of all kinds in the United States shall be a thing of the past. In Canada very much the same thing has taken place, though the work in Canada is usually more solid than in the United States, the other advantage was present—viz., the absence of vested interests, to a large degree; and Canada has been distinguished for some time by a desire to profit by the experience of her great neighbour, but to apply the experience more in English than in American fashion; and so the cities of Montreal, Ottawa, and others have possessed the advantages of electric tramways for some years past, though the conditions in some of them in the matter of gradients are very severe.

On the Continent also, though Germany cannot be said to be a new country in the sense that America is new, it is new in the efforts it has been making to improve its methods generally since the War 1870. And the fact also that Germany had been backward before, while this country had been forward, operated strongly in favour of the new movements which were going forward, in that there were fewer vested interests to be reckoned with. It would appear also that those who were possessed of vested interests did not insist on their pound of flesh, in the manner in which strictly commercial principles, such as dominate all our ideas in this country, would have dictated. And so it has come about that in all parts of the Continent the movement for driving tramways and branch railways by electricity, following on the adoption of the electric light, has also gone forward by leaps and bounds. Even Switzerland has followed the general movement, and has fitted some of her mountain railways for driving by electricity, as well as some of her cross-country traffic of a heavier nature; and she has taken the important step of using polyphase alternate currents.

Meanwhile we in England have been thinking over the matter very seriously. In the early nineties, an experimental line was fitted up by American engineers in the outskirts of Leeds, from the top of Briggate to Roundhay Park. But though this line showed what could be done, it did not meet with much favour, though Leeds at that time was in the hands of the steam tramway. The network of overhead wires which appeared to be necessary, especially at junctions, was felt to be very objectionable, and in addition, at Leeds, all the usual vested interests appeared. Apart from the tramway already in existence, the National Telephone Co. claimed the earth, in the sense that, as their wires at that time were all connected to earth, and as they were first in the field, and as the passage of the return currents of the tramway service by the rails, which were also in those days very

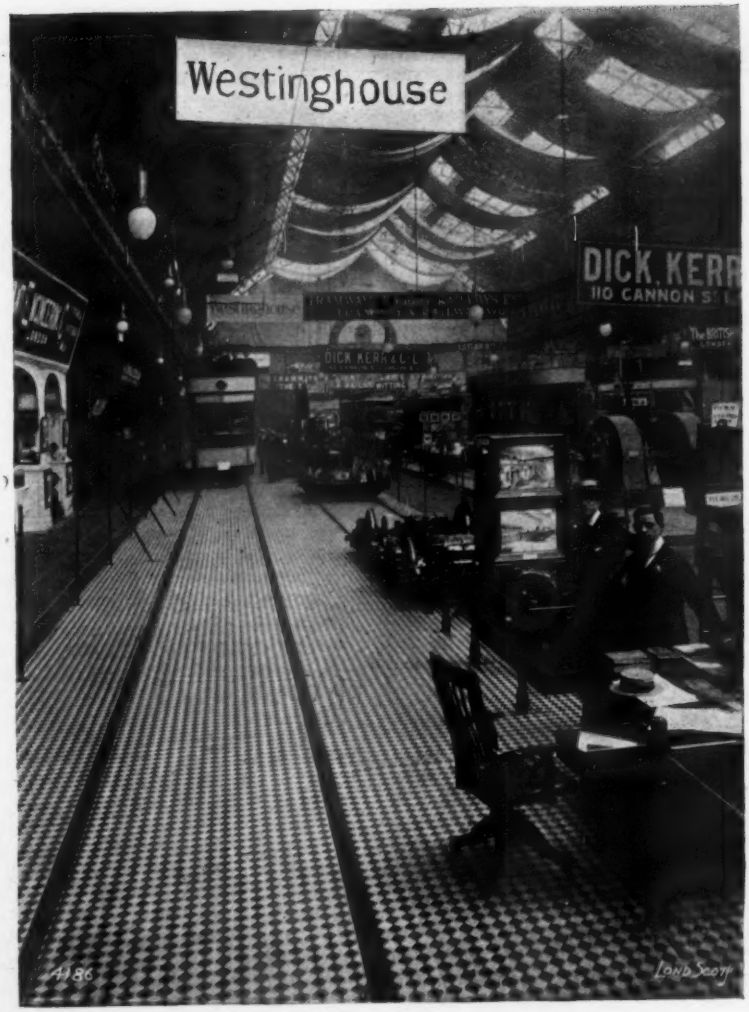
much more imperfect than to-day, caused considerable trouble with the telephone messages, they claimed to prevent the use of earth by the tram lines.

But meanwhile other things had been happening. Owing to the great incubus of the vested interests in the cases of the old gas and water companies, the Electric Lighting Acts of 1882 and 1888 gave important preferential rights to local authorities, and after a few of the most go-ahead towns had led the way with the light, nearly every town of importance followed. It was the fashion, and councillors did not like it to be said that their town had not the latest illuminant. It was also supposed that large sums would be made by the electric lighting undertakings, which could be used in aid of the rates of the different towns. Numerous companies were anxious to secure the areas available in nearly every town, and as it was a foregone conclusion that these companies would not be so anxious to undertake work of the kind unless they hoped to reap handsome profits, it was felt that it was the duty of every council which had the welfare of its town at heart to secure the expected profit for the ratepayers. But as in many new undertakings there was a slight miscalculation. It was known that gas companies were making large profits, but it was forgotten that the conditions under which gas is produced and distributed to consumers are different from the conditions under which electricity, at that time at any rate, had to be generated and distributed. Gas is generated and stored, the generation taking place whenever it is convenient to the gas engineer, provided that he has a supply of gas always available. With electricity, though a storage battery was available, and was used, even in some of the very early electric lighting stations, notably Kensington and Knightsbridge, the storage problem was a very different one from that of gas storage, and in addition the storage battery itself is even to-day not all that could be desired, and it was very much inferior in the early days of town lighting. Further, the engineers who were responsible for the laying out of several of the early electric lighting stations deliberately cut themselves off from all possibility of using such storage as was available by the adoption of the alternate current. At that time the scheduled areas in nearly every case were such that they could have been well supplied on the low tension, three wire system, as the successful towns of Bradford, Glasgow, Manchester, St. Pancras, and others did, and the development which naturally came, as soon as the light became certain, and was somewhere near gas in price, could have been dealt with, as it has been dealt with in those towns, by the adoption of 200 and 250 volt lamps, still on the three wire system, alternate currents only being advisable later on. Unfortunately there is a fashion in engineering, as in most things. When the great beauty and flexibility of the alternate current system of distribution came to be appreciated, there was a craze for its adoption, and it was adopted in very many cases where it was quite out of place, and where a preliminary calculation would have shown that it could not pay. In addition, again, it was naturally felt that if electricity was to compete successfully with gas for lighting, it must give at least as good a service. There must be not only no chance of the light failing, but it must be available whenever gas was. In the case of sickness, a light might be wanted in the middle of the night, and in the case of men going to business early in the morning in winter, the light must also be available. Hence it became necessary to install a large and expensive plant, which in the majority of cases was only in use for three hours out of the twenty-four at the outside during the winter months, and scarcely at all during the summer months, while all the time arrangements must be such that light was available up to the full extent of the lamps that were connected at any hour of the day or night; and this meant the provision of a staff on duty for the whole 24 hours. The result of this was that few towns succeeded in even clearing sufficient to pay the interest and the sinking fund which the Board of Trade insisted should be provided, much less in setting aside anything for the relief of the

rates. The rates, in fact, had to aid the undertakings. And in all those cases where the alternate current apparatus had been installed, the committees who were responsible for the work had also cut themselves out of a relief which came at an early date to the towns which had adopted the continuous current—viz., the motor load. The convenience of the electric motor was quickly discovered, aided by the efforts of the numerous contractors who were doing the wiring in every town, and in continuous current towns a day load, consisting of motors used in factories of varying size, soon began to grow up, aided, in some towns, such as Bradford, by the adoption by the Corporation of the policy which the gas companies have adopted with gas stoves, the rental of motors on easy terms, the consumption of gas, or of current, amply paying for the investment. With alternate current towns, however, this was not possible, and engineers began to look round for additional sources of possible consumers. Then came the induction motor, and, later, its modification applicable to single phase currents. This provided a slight assistance, but it was not much, as the new motors possessed attributes in their disfavour which the continuous current did not.* Then came accounts of the wonderful success of the tramways in America and on the Continent, which was followed by the establishment of the Liverpool overhead railway, the Potteries tramway and other undertakings, all of which seemed to be doing well, and then the City of Bristol took the matter up, not in its corporate capacity, but as a private venture among certain of its citizens. It was soon felt that here was the customer that corporations who were losing money in electric lighting schemes, wanted. The Corporation of Bristol tried hard to secure the supply of current for the tramway service, but the company who were running the tramways would have none of it, they could generate current much cheaper themselves, they said; and the lesson was taken to heart by other corporations who were in a position to either lay out new tramway lines, or who could obtain control of the lines in their districts. New committees arose in the corporations, who wished to have some of the glory which had fallen to a limited extent upon the lighting committees, but without the financial losses which had attended the efforts of those bodies. Another matter also helped the development of the electric tramway service—the striking increase in the population of all large towns, owing to the continued exodus from the country districts. The housing problem began to be a serious one. Glasgow had set the example of buying a district outside the city, building workmen's dwellings there, and providing a cheap service of trams to them. Combined with electric driving, this promised to cure the trouble right away. Also nearly all the large towns have been extending their borders from time to time, taking in residential suburbs, and it was felt that electric trams supplying these would reconcile the outsiders who were in many cases reluctant to come in. The electric service incidentally had another great advantage, which the American pioneers early discovered—it enabled a rapid succession of cars to be run without unduly increasing the dead costs. The increased earning power of electric tramroads is, perhaps, as much due to this as to cheap and rapid service. The passenger who arrives at a tram route, and sees the car he wants to travel by some distance ahead, if there is no other car for some minutes, walks, but if he knows that another car will follow very shortly, as is arranged in all the large towns, particularly at the busy time, he will wait for it, and the tramway service obtains all the possible traffic.

But the most important cause of the present rush for electric tram and railways has been the striking success of the Central London Railway, the "Tuppenny Tube" as it was at first irreverently, and is now affectionately called by the Londoner. Railways of the kind were not exactly new. The City and Waterloo had been running for some years, but it was on a

* With the improvement of the single-phase induction motor this trouble is largely disappearing. Sheffield, for instance, has connected up 500 h.p. of single-phase motors in the last twelve months.



GENERAL VIEW OF THE BRITISH WESTINGHOUSE COMPANY'S EXHIBIT.

small scale. The City and South London had also been running for some time, but it hardly appealed to the class to whom the Central appealed, the great body of residents of the West End of London. Its success also was due as much to the striking administrative ability of its designers as to the fact that it was run by electricity. The beautifully lighted stations, the careful shepherding of the passengers, so that it is difficult for anyone even from the country to go wrong, the entire absence of all trouble as to tickets and as to where one's carriage is, as well as the rapid, clean, and quickly succeeding service, and low fares for the whole journey, brought its usual reward. The success was instant and complete, and a fairly substantial dividend was paid the first half-year. Further, it has since appeared that the Tube has created a traffic of its own. Men go by it who, according to the rule of taking the shortest route, should not, such as men living at Earls Court and wanting to get to Charing Cross or the neighbourhood, take two busses and the Tube, and save in time and cash over the alternative route by the Metropolitan District. The Tube is stated to have carried over 5,000,000 passengers in its first year. It is a very old saying that nothing succeeds like success, but it is equally true that nothing is more copied than the apparent means which have led to success. The Tube is worked by electricity, and the whole of the credit is given to electricity, and now London is to be riddled with Tubes, from and to all quarters; all towns are to have electric trams, and all light railways are to be electric. But as already indicated, the use of electricity is not to be confined to tramlines. Mr. Langdon, in the paper referred to, "The Supersession of the Steam Locomotive," in which he has discussed the feasibility of working a section of the line, from London to Bedford, by electric locomotives, estimates the saving per train mile at 1·922*d.*; and in this he has rather shown the caution of the experienced engineer than the enthusiasm of the pioneer. He has based his estimate on the supposition that the steam locomotive will be superseded by an electric locomotive, which will occupy the position the steam locomotive does to-day, except that, as in the Central London Railway and in tram lines, the locomotive will take its energy from the third rail, instead of from the coal carried on its tender. In this he is probably underestimating the saving that will actually be effected, but he is bowing to the natural feelings of railway men. To the railway engineer it seems in the natural order of things that there should always be something at the head of the train, pulling it along. There has always been something. Where men pull carriages, as in Japan, where horses pull them, and where steam locomotives pull trains, it is always necessary to have something in front; but with electricity it is not necesssary. On the Chicago South Side Elevated Railway, on the new Metropolitan Railway of Paris, and other lines, the car itself, or at most two cars, as with electric tram lines, is the unit; every car, or every other car, being provided with its own electric motor and controlling gear, so that trains can be made up or divided as may be required without the necessity of shunting; and this brings a considerable additional saving which will be felt as the system is better understood.

The fact which has been referred to above also, that an electric service is always run at more frequent intervals, is the outward sign of an important truth. With the horse, the man, or the steam locomotive, the power that can be exerted is strictly limited by the ability to carry sufficient store of energy-producing material, or to provide sufficiently frequent replenishment. With electric driving, the power that can be exerted is limited only by the ability to distribute energy in such a form that it can be taken up by the locomotive in passing, and this is only limited by the pressure that can be used in the distribution system, which is again only limited by the possibilities of insulation. As the possibilities of insulation are increasing almost daily, it may be said that for practical purposes the possibilities of power for electric driving are unlimited, and consequently the possibilities of the railway service of the future, so far as power is concerned, are unlimited, or

merely depend upon the working out of practical details, such as have been worked out in other directions with uniform success.

There can hardly be any doubt therefore that the supersession of the system of driving our railways by steam locomotives will only continue as long as it is convenient to engineers, while they make their arrangements for displacing them, or as long as financial reasons dictate.

The Exhibition.

It is two years since the first exhibition devoted entirely to the electric tramway and railway industry was held, and the impetus given to the schemes of traction development in town and country by that enterprise proved to be so strong that, in the comparatively short interval separating the first from the second exhibition, capital investments in this class of undertaking have increased by over £42,000,000, including the amount represented by the huge works that have sprung up to meet the demand for electrical equipment.

Although there were over twice as many exhibits in the recent exhibition as in the first, there were, with one or two exceptions, no very startling departures. Improvements certainly had been effected, and it has been perhaps in the perfecting of small details that progress has been made.

One of the most striking groups of exhibits was that of

THE BRITISH WESTINGHOUSE COMPANY

whose new works were described in our last issue. The equipment shown included some of the most modern and interesting machines used in connection with both lighting and traction, most of which were shown in operation as in actual practice.

As will be seen from the photograph, the stand extended over the entire length of the Hall, on which a tramway track 310 ft. long and equipped on the side pole, overhead trolley system was laid down. A large modern car, similar to those supplied by this company for the Tyneside tramways, ran up and down, current being supplied by a gas-electric generating set which formed a side exhibit of this firm.

The gas engine is of the type introduced by the Westinghouse Company some three years ago, and which was fully described in FEILDEN'S MAGAZINE, Vol. I., pages 490 to 492. It is of the three-cylinder type, each cylinder being 13 ins. diameter by 14 ins. stroke. The rated output is 112 b.h.p., but by using illuminating gas of good quality its output is increased to about 130 b.h.p. The cylinders are all single acting, each piston receives one impulse every other stroke, and the three cranks being set at 120 degrees with each other, the crank shaft thus receives one propelling impulse every two-thirds of a revolution.

The generator which was direct-connected to the gas engine is of the well-known Westinghouse multipolar direct-current type, has a capacity of 75 kw., and yields current at 500-550 volts.

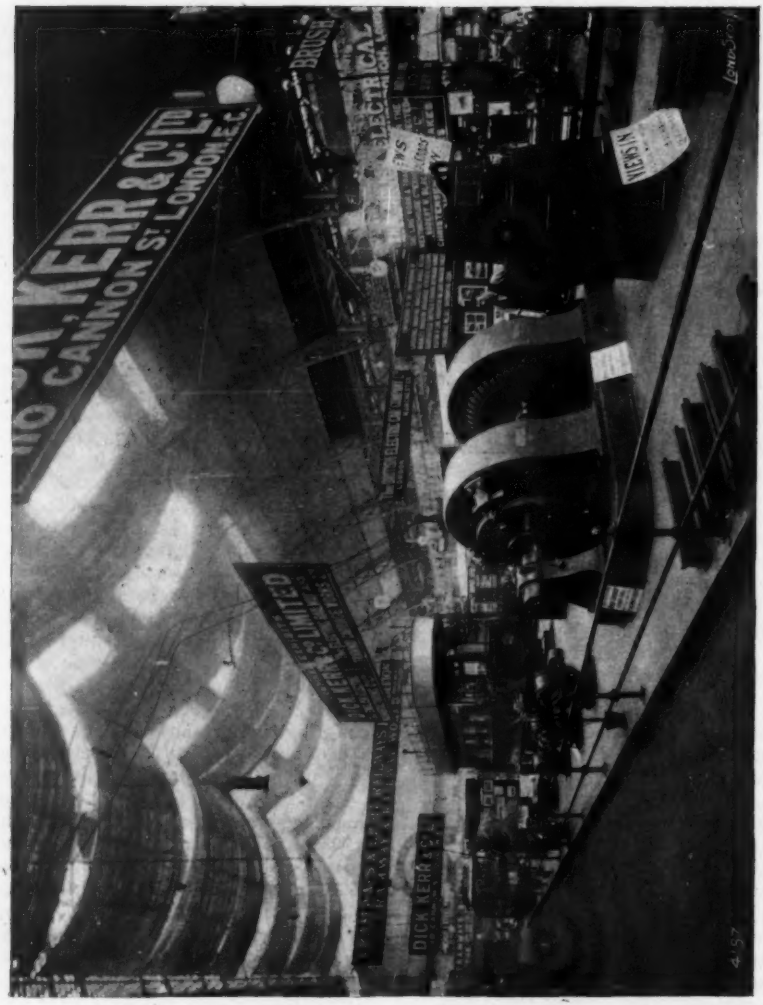
The Newell magnetic brake formed one of the most interesting of the electric-traction details shown. It comprises (1) a double track-shoe, combined with a powerful electro-magnet which, when energised by current, produced by the car motors when acting as generators, is strongly attracted to, and grips the rails by magnetic force; (2) brake heads and shoes of the ordinary type, acting directly on the wheels, and constituting a wheel brake of maximum power and efficiency; (3) sundry castings and forgings for simultaneously transmitting the downward pull and resultant drag of the magnetic track-brake into lateral pressure on the wheels. In addition to this equipment, the brake includes brake controller attachments for use when the motor controllers are not provided with braking points, and a diverter, or improved form of rheostat for dissipating the heat generated by any excess of current over and above that required to operate the brake when the heaters, which may be installed with the brake, are not in service.

Other examples of Westinghouse equipment included various types of tramway and stationary motors, and the new Westinghouse-Bremer arc lamp.

Very attractive and important were the joint exhibits of

MESSRS. DICK, KERR & CO., LTD.,

the English Electric Manufacturing Co., and the Electric Railway and Tramway



MESSRS. DICK, KERR AND CO.'S STAND AT THE TRAMWAYS EXHIBITION.

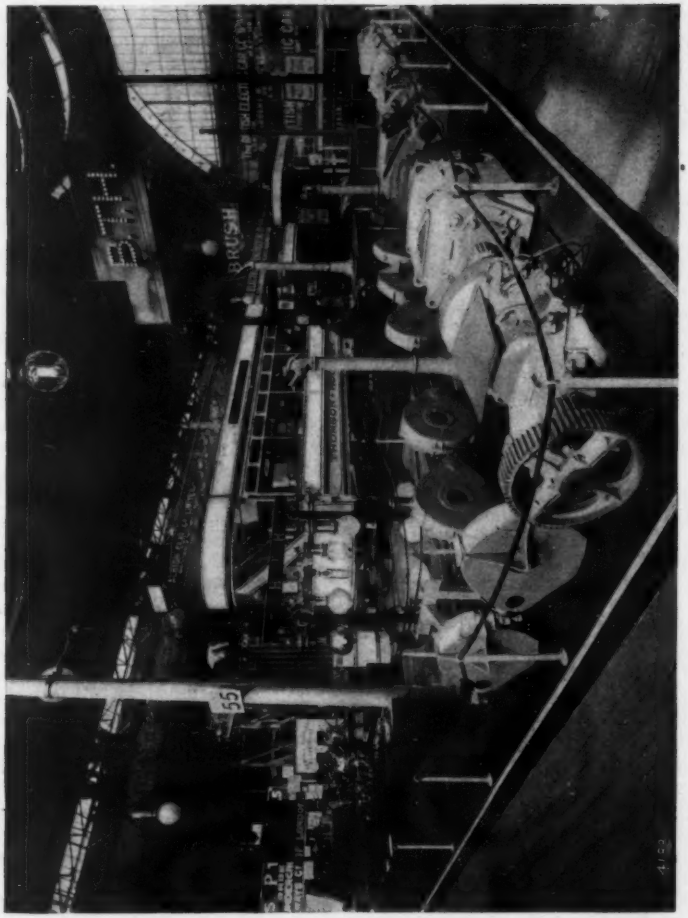
Carriage Works, which included a very handsome car, one of the first of a hundred being built for the conduit line of the London County Council.

It bears considerable resemblance to what is known as the "Preston" type with Bellamy reversed stairway, which has been supplied by Dick, Kerr & Co., Ltd., to many of the tramway systems in this country. The seating capacity is sixty-six passengers, twenty-eight inside and thirty-eight outside, the total length over all being 33ft. 6ins. The frame of the car is so arranged as to accommodate on each side two large fixed windows in the centre, and four end windows arranged to lower. Above the windows is a line of narrow, ornamental pivoted sashes provided for ventilation, this being a distinctive feature of the Preston car. At each end of the car are provided route-indicator boxes with revolving linen screens. A new feature in the interior of the car is a glazed partition dividing the seats on each side. The interior woodwork is of quartered oak, the end doors sliding in the usual way, and fitted with the necessary handles, catches, etc. The roof seats will, as already stated, carry thirty-eight passengers, and will be of the garden type with angle-iron legs. The car is mounted on maximum traction bogies of the Brill type, each bogie carrying one motor. The electrical equipments are in most respects similar to those usually supplied by Dick, Kerr & Co., the notable features connected with the motor being the freedom from sparking of the commutator under all conditions of load, and its high efficiency. The plough attached is similar to that employed on the Paris conduit system.

Another feature in the joint exhibits was a single-deck combination vestibule car built to the order of the Sunderland Corporation Tramways, the main feature in the design of which is the provision of both outside and inside seats upon a single deck, giving also ample room for passengers alighting from or boarding the car, and consequently reducing the time necessary at the stopping-places. The car is built to accommodate thirty-four passengers, sixteen inside and eighteen outside, and has an over-all length of 30 ft. 10 in. over the buffer irons, and a width of 6 ft. over the side sills. The truck is of the 21E Brill type of standard design, with 6 ft. wheel base and 30 ins. wheels. The under-frames are of oak in combination with steel sole bars, and ensure a maximum of strength with a minimum of weight. The platform frame, which is an important factor in this class of car, is formed by continuing the side-frames to the necessary length. The car is of the "Vestibule" type, offering complete protection from the wind and weather to the motor-man, and diminishing the draught to the outside passengers on the platforms. The vestibules are furnished with balance blinds and windows, one on each end, constructed to drop if required. In order to ensure the safety of the passengers riding on the open portion of the car, the near-side of the front platform and the off-side of the rear platform are panelled in, the panelling being surmounted with wrought-iron scroll work, the remaining portion of the platform being closed with a folding gate. On the off-side of the front platform and the near-side of the after platforms are folding gates. The whole of the open portion occupied by the passengers is adequately protected from the weather by storm blinds.

Prominent in the foreground of the photograph of this stand will be noticed a combined motor-alternator, built at the Preston Works for the Portsmouth tramways. The combination consists of a direct-current shunt-wound motor direct coupled to an eight-pole three-phase alternating-current generator, the two machines being carried on the same bed-plate. The output of the generating side is 200 kilo-watts when supplying current at 5,500 volts, and running at 375 revolutions per minute, and 25 cycles per second. The motor is a four-pole shunt-wound machine, running at 550 volts.

Various sizes of standard traction motors are also exhibited, but the method of construction is practically the same. The motor-frame, consisting of two bowl-shape castings, is divided horizontally, and so arranged that the bottom half may be lowered out so as to permit inspection of the interior of the motor without



THE BRITISH THOMSON-HOUSTON STAND AT THE TRAMWAYS EXHIBITION.

removing the armature. On the motor frame are four poles built up of laminated sheet steel punchings, each pole being divided by a gap into sections, thereby adding considerably to the cool running of the machines. The field coils are all alike, and interchangeable. The armature is of the slot type, being built up of laminated punchings; the armature coils are former wound and interchangeable. The aim of the designers has been to provide a machine which will run economically and sparklessly under all conditions of load and rail, and experience has shown that these expectations have been more than realised.

The exhibits of

THE BRUSH ELECTRICAL ENGINEERING CO., LTD.,

included two types of cars, the first being of the double-deck type, mounted on a single truck, with a carrying capacity of 62 passengers, the second car being one of a large number of a familiar type, built to the order of the Manchester Corporation.

The trucks shown represented those that are at present being manufactured by this company, viz. :—

(1) Single or four-wheeled truck.
(2) Unequal wheel bogie or maximum traction truck.
(3) Equal wheel bogie truck, either maximum traction, or for four motors to each car.

The single truck combines all the best qualities of such trucks now in use in Great Britain, and many improvements which experience has proved necessary.

The three-quarter elliptic spring gives a longer spring base than a half elliptic or a full elliptic spring—a half elliptic taking one-half of its load close to the coil spring, and the full elliptic its entire load through the centre of band, while the three-quarter elliptic takes two-thirds of its load through centre of the band and one-third at a point fourteen inches out, making the mathematical spring base longer than in any other type. This long spring base, together with the check spring below the frame, will carry a long car body as steadily as the other types carry a shorter one.

The semi-elliptic springs over the journal box with their link suspension, act in the same way as the swing bolster in the bogie truck, and enable the truck to negociate curves much more gracefully than with coil springs: besides, the placing of four springs within and four without the frame gives a good foundation for the side frames, and prevents them from twisting themselves loose from end sills, motor supports, etc.

Bottom straps and tie bolts prevent the hornplate from pinching the journal box, and interfering with the spring movement.

The journal boxes are large and roomy, permitting of ample store of lubricant, the box lid being machine fitted, and the arrangement of the dust proof back, together with brass and keeper in one piece, makes them the simplest and best journal boxes.

The brakes are of the rocker shaft type fitted with elastic hangers which automatically take up their own wear, thus effectually preventing lost motion (which would cause them to kick or rattle), and also the communicating of any movement to the car body by sudden application of the brakes.

There are four stops (one at each horn-block or pedestal), which relieve the springs of the duty of checking the car body when rounding curves and turn-outs, and throw these strains on the horn-block, which is much better able to stand them.

The whole truck is simple in design, and contains fewer parts than any other now on the market.

A type of maximum traction truck was shown which differed from the standard in having an adjustable traction device, which permits of varying the load on the driving wheels from 60 to 80 per cent of the total load.

Special attention was paid to the stand of the

BRITISH THOMSON-HOUSTON CO., LTD.,

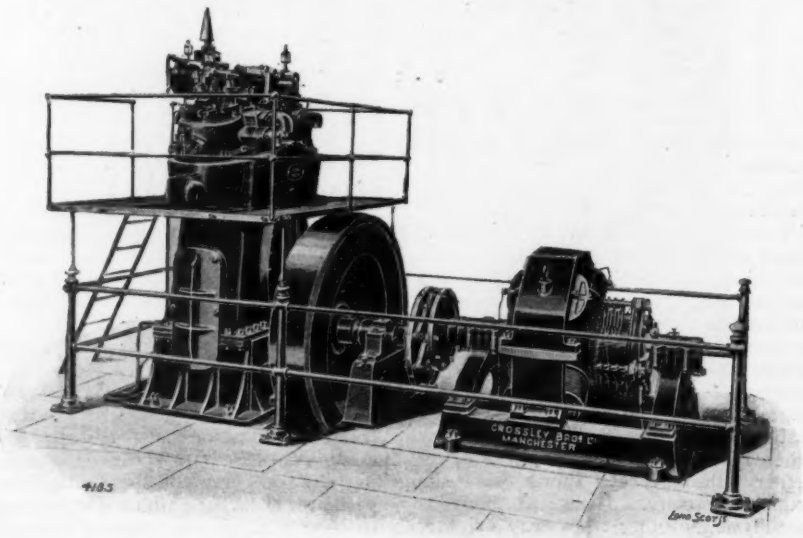
which included, amongst other things, a complete exhibit of that firm's system of master-control. This system is intended for use on lines dealing with heavy passenger traffic, and where it is necessary to have a rapid and frequent service of trains with a high rate of acceleration. Further, where trains must be capable of

operation in either direction and from either end, so that time and space required for the shunting of a locomotive at crowded termini be avoided, the above system is a good one. After a thorough investigation of the merits of the different systems of control, the Great Northern and City Railway Company decided to equip their trains with the master-control system of the B.T.-H. Co., which specially meets their requirements, and which permits the cars to be run singly or combined in trains of any size, the operation being controlled from any one controller. Two trains equipped with this system are now in satisfactory operation on the Central London Railway. This system has also been adopted by the Manhattan Elevated Railway of New York, U.S.A.

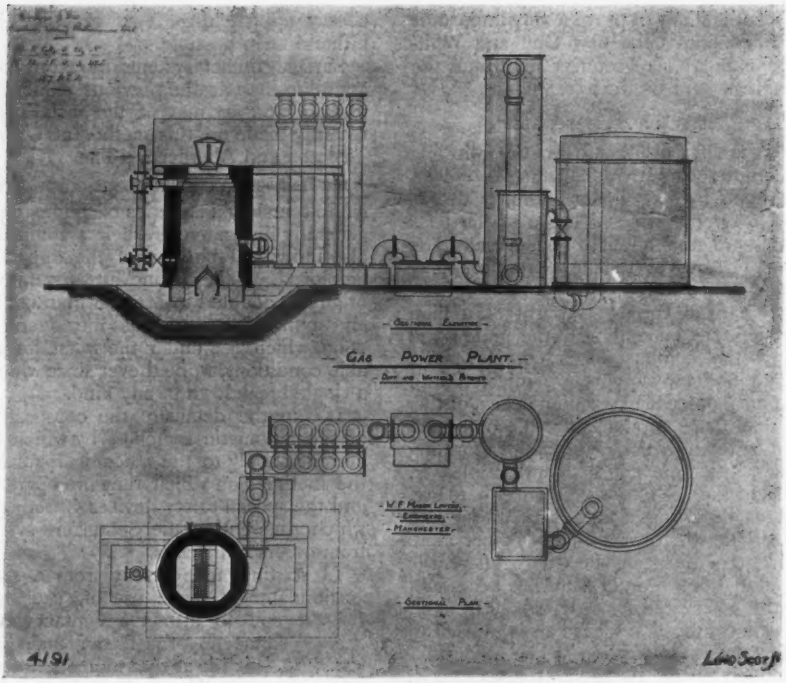
MESSRS. CROSSLEY BROTHERS

were, as usual, *en evidence* with a fine show of gas engines, the most important and interesting of which was a double-cylinder inverted vertical gas engine—the first of its kind exhibited by this firm—combined with a dynamo.

It has many features of great interest. The engine has two cylinders, with both connecting rods leading on to the same crankpin. The cylinders are 11½ in. diameter, by 15 in. stroke, made with water jackets, and fitted with loose liners, in accordance with the firm's usual practice. The pistons and cylinders are of specially hard metal, and the connecting rods are made from steel castings, and large phosphor bronze adjustable bearings are provided. The engine framing stands on a massive casting. The crankshaft is made of mild forged steel cut out of the solid, and is machined and polished, and fitted with balance weights. An outside bearing is provided, and a pedestal for carrying the outer end of the crank-shaft. The side-shaft wheels are machine cut, and have spiral teeth. The engine is fitted with an efficient high-speed governor, by means of which the speed can be adjusted at pleasure, and which automatically regulates the consumption of gas in proportion to the load on the engine. In addition, each cylinder is provided with an automatic cut-off valve under control of



DOUBLE-CYLINDER INVERTED VERTICAL GAS ENGINE BY MESSRS. CROSSLEY BROS.



DETAILS OF THE DUFF AND WHITFIELD PATENT GAS PRODUCER.

the governor, which regulates the power given out by the working strokes, and enables the engine to run without cutting out ignitions down to or below half load. Each cylinder is fitted with timed ignition valves, which ensure economical working under varying conditions, and prevent waste of gas. The engine is also fitted with patent safety gear, to prevent its turning the wrong way at starting. The charge is ignited by means of porcelain tubes which are very quickly heated, very durable and extremely cheap. Each cylinder has a duplicate igniter, which prevents the engine stopping in the event of one tube breaking. The side shaft is of mild steel, turned and polished. Very efficient lubrication is provided, the oil being pumped to an oil box, from which it is distributed by means of pipes to the various parts. The engine has a heavy fly-wheel 7 ft. 0 ins. diameter by 21 ins. wide. It is built for giving off about 55 b.h.p., when working with producer gas, at a speed of 250 revolutions per minute. Crossley's Patent Starter is provided for starting, and the engine has all the usual accessories, such as gas bags, silencers, etc. The mechanical efficiency of this engine is guaranteed not under 85 per cent., and the variation in speed, including both cyclical and governing, when running at a load between half power and full power, will not exceed 1 per cent. The engine was combined, by means of one of Raffard's Patent Elastic Couplings, with a Mather & Platt Multipolar Dynamo, shunt wound. A very neat and light wrought-iron platform is provided, with ladder, etc., for getting to the cylinder and higher working parts of the engine.

What is likely to prove a very important development, is the new Duff and Whitfield Patent Gas Producer, of which the drawings were shown by

MESSRS. W. F. MASON, LTD.

We are in a position to give the following preliminary information, which, however, we hope to supplement by fuller details and diagrams on completion of the tests which are now about to be made. The chief features of the new producer may be described as follows:—

The fixed carbon is burnt at a high temperature on and near the grate; and when the combustion is complete, the steam and tar vapours are injected into the incandescent mass. The effect of this is that these products are decomposed, and enter into the combinations forming gases, which are entirely combustible, viz. H and CO. These products, therefore, act as enriching agents, which they can hardly do when air with its 75 per cent. diluent of nitrogen is used to effect the combination. Air, of course, is necessary, but the sensible heat developed from or by the combustion of the air is utilised to effect the decomposition. The vapourised products from the coal, together with sufficient gas produced below the outlet are made to circulate, and thus keep the temperature at the outlet high enough to prevent any tar vapours being formed at or below the outlet.

The grate has more air space on the side facing the vapour outlet, because the temperature has to be maintained higher on this side. The opposite of the grate is only kept burning sufficiently to maintain incandescence and to insure the formation of CO. The reason for this is that the gas made on this side of the grate is only similar to Dowson or ordinary producer gas, and is not enriched by the addition of the products of decomposed steam and tar vapours, as is that produced on the opposite side. It is entirely due to this enriching process that the apparatus is capable of generating gas from ordinary bituminous coal of a calorific value of 185 b.th.u. per foot. This high thermal value is invaluable in furnace work, and produces results in the gas engine more closely approaching town gas than has hitherto been possible.

Surface-contact systems attracted more attention than at the previous exhibition, probably on account of the installations recently made on this method at Wolverhampton and Aberdeen. The

BRITISH SCHUCKERT ELECTRIC COMPANY'S

exhibit included a series of photographs generally illustrative of their system, and also individual portions of the apparatus employed. The Schuckert system was originally adopted in Munich in 1896, but an improved system was introduced in 1899, which has, under the worst imaginable conditions, worked ever since without a single breakdown of any kind.

It is in the details of the construction of the automatic switches, by which the current supply to the studs is regulated, the methods on which they are operated, and the special safety devices introduced, which differentiate the Schuckert system from others of its class.

In starting, the current from a small accumulator is made use of, causing a magnet coil to attract a contact lever, thereby connecting the feeder main with the stud, which is at that moment in contact with the collector skate fixed under the car, thus enabling the car to proceed. Then the advance relay in the direction travelled is excited, and closes the circuit immediately its respective contact-block is touched by the skate, while the draw-off coil of the surface contact just passed by the collector, but still beneath the car, and which is energised by a shunt current of the advance apparatus, attracts the contact-lever, and switches the respective section. This series of operations is repeated as the car proceeds. The

KINGSLAND ELECTRIC TRACTION SYNDICATE

were also showing details of the system exploited by them, which was fully described in Vol. V. of FEILDEN'S MAGAZINE, pp. 77—81. This system, of which we had an opportunity some time back of inspecting an experimental length at Wolverhampton in effective operation, has for its salient feature a mechanical method of switching the current on to the usual contacts.

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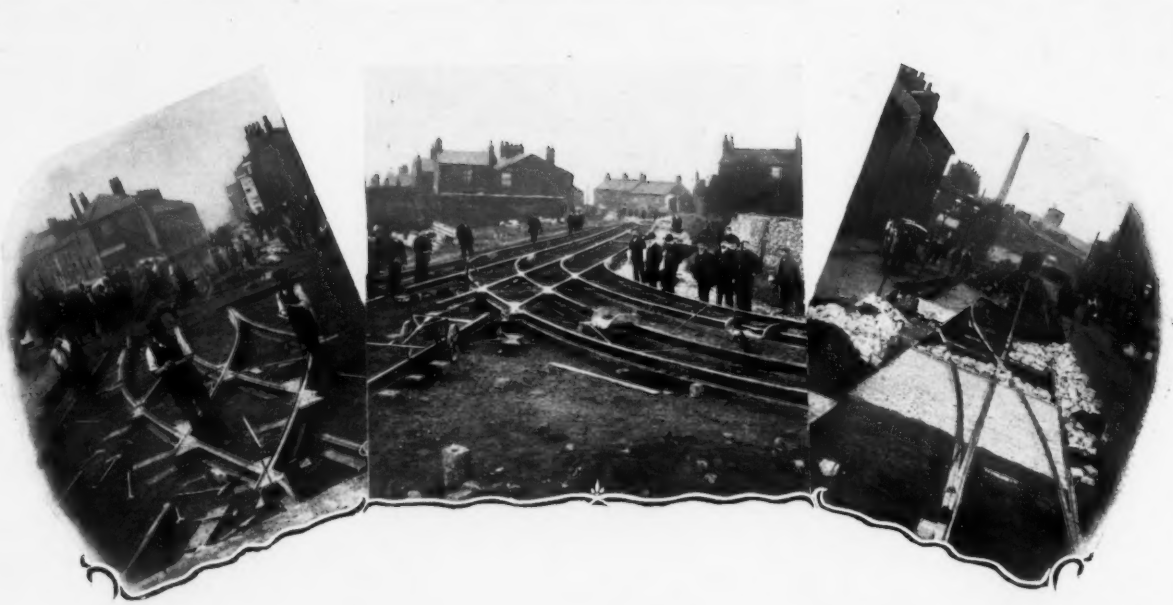


EXAMPLES OF SPECIAL TRACK-WÓRK, CONSTRUCTED FOR THE OLDHAM TRAMWAYS
BY MESSRS. ASKHAM BROS. & WILSON, Ltd., SHEFFIELD.

The switch is positive in action, cannot overrun itself, and "make" and "break" with 600 volts gives not the slightest sign of fusion at the contacts. Several of the switches have been placed under a fly-wheel striker, and subjected to upwards of 300,000 blows at speeds varying from ten to twenty-two miles an hour without showing the slightest sign of wear in the mechanism. This is equal to about two years' wear with a five minutes' service running eighteen hours a day.

Germany, awarded this contract for about 60 miles of line material, the whole of which was made entirely at the Birmingham works.

The finest exhibit of permanent way material, was that of

MESSRS. ASKHAM BROS. & WILSON, LTD.,

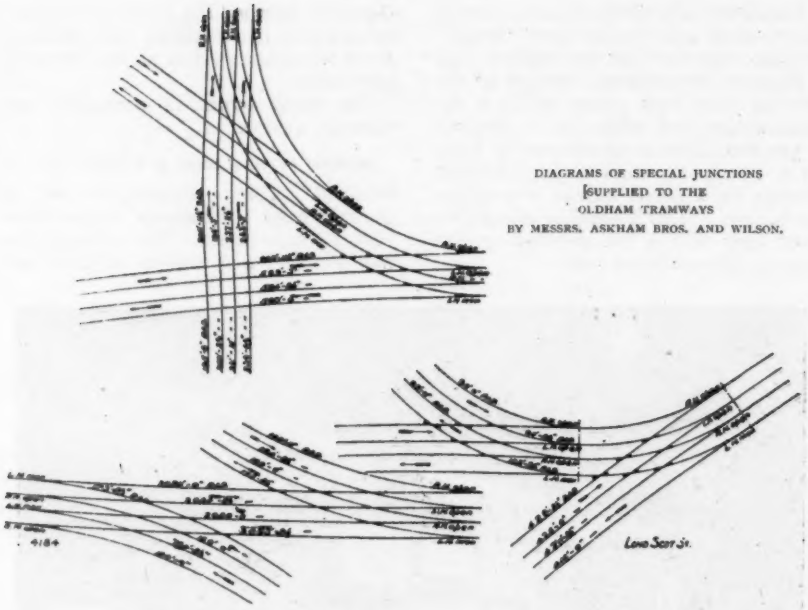
Sheffield. They occupied one end of the hall, from the entrance to the Minor Hall, 88 ft. in length. The whole of this was occupied with samples of their best

MESSRS. ASKHAM BROS. AND WILSON'S STAND.

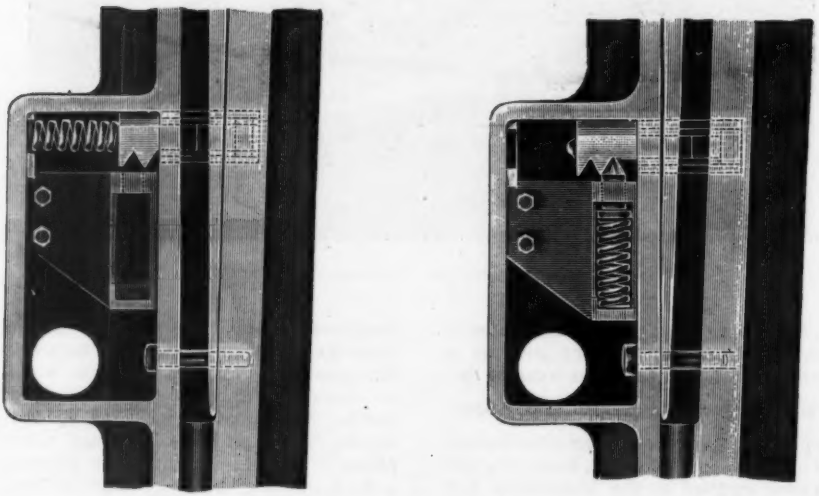
Many were the overhead line materials that were on view, but space prevents us to do more than refer to the stand of the

ELECTRIC TRAMWAY EQUIPMENT COMPANY

in particular, where were numerous samples of insulators, pull-offs, ears, frogs, etc., such as were supplied to the Manchester Corporation. It is gratifying to learn that the Equipment Co. were, in spite of the recent severe competition from America and toughened crucible cast-steel points and crossings, supplied to various tramways throughout the country, amongst which we noted chiefly: Liverpool, Sheffield, Leeds, Nottingham, Huddersfield, Yarmouth, Manchester, Dublin, and other places. The chief points were straight, 9 ft. 0 in. long, but they were showing samples of curved points from 60 ft. to 200 ft. radius, to suit the requirements of tramway engineers. They inform us the



DIAGRAMS OF SPECIAL JUNCTIONS
SUPPLIED TO THE
OLDHAM TRAMWAYS
BY MESSRS. ASKHAM BROS. AND WILSON.



AS AUTOMATIC. — AS MOVABLE.

MESSRS. ASKHAM BROS.' COMBINED AUTOMATIC-MOVABLE POINT.

sharper radius is chiefly for depôt work and junctions. They were showing some special points for Manchester 10 ft. long and 200 ft. radius, which were greatly admired by engineers. In the permanent way there has not been very great advances during the last two or three years, but Messrs. Askham showed us the most "up-to-date" points, viz.: silent points and auto-movable. This latter point is viewed with very great favour by every engineer who has examined same. Its normal position is an automatic point for a single line, but when required it can be converted into a movable to enable the cars to run back from that particular point without having to cover unnecessary ground. This is of very great service in cities, where very frequently crowds assemble upon different public matters, and stopping tramway traffic. The point enables the manager to work his cars to advantage. We illustrate two sections of this point, one as an automatic, and the other as a movable. Of recent years complaints have been made with regard to the noises in the street. The automatic point certainly gives a "click" when closing, and while certain of the public object to this, drivers prefer it, as they know the point is set right for the returning car. However, Messrs. Askham have an excellent silent point, which carries its name out in every way, as the tongue closes perfectly noiselessly. The cost of this is very trifling compared with the luxury obtained.

We also saw a model of a portion of a special junction, executed in crucible cast-steel, for the Oldham Corporation. Messrs. Askham had prepared the entire junction for the Exhibition, but time exigencies would not permit of the castings remaining for so long a time, but a large photograph, showing the junction complete, fully explained what had been supplied. We have been informed that there is more special work at Oldham than in most towns in England, and we therefore made personal enquiries on the matter; and, owing to the courtesy of the Borough Surveyor, Mr. S. A. Pickering, we are able to place before our readers some interesting facts. Our frontispiece shows three junctions under construction at Oldham, and we also show diagrams of one or two special junctions as laid there, and only regret that the extent of ground occupied by these junctions prevents a satisfactory photograph being taken. Over six months was occupied in getting out one street and its connections, owing to the large amount of special work necessary, the whole of which was constructed by Messrs. Askham Bros., with, we understand, very satisfactory results. There are 32 double junctions in the system, besides numerous passing-places, turnouts, which will give some idea as to the special work, all of which has been supplied by Messrs. Askham Bros. Approximately, 180 pairs of points and 279 crossings have been used on the contract up to date. Tie-bars and fish-bolts were also supplied by Messrs. Askham. The rails were supplied by Messrs. The Barrow Hematite Steel Co., Ltd., of a special section, weighing 100 lbs. per yard.

We also noticed a selection of special joint plates of various types, of which over 500,000 have been supplied throughout the country.

An object-lesson for the committee on standardisation was also on view, in the shape of a chart, showing roughly about 200 rail sections that have been prepared to specification from time to time by Messrs. Askham Bros. & Wilson. While many of these were for special point and crossing work, nevertheless, the majority only differ from each other in details of not sufficient importance to justify the additional expenditure of preparing a fresh pattern.

As representing another important element in electric tramway construction, mention may be made of the high-tension sub-station and low-tension continuous-current boards shown by

FERRANTI, LTD.

The former, which is designed for use on a three-phase system, has provision made for controlling two incoming feeders, and the primaries of three static transformers, connected delta-fashion for sub-station working.

MESSRS. MELDRUM BROS.' STAND.

A panel is provided for a fourth transformer, which can be used as a substitute for either of the other three in case any one of them should break down.

This board comprises a very compact and easily operated gear, and is absolutely safe as regards danger of shock. All live parts are placed at the back of cells, and are out of reach of the attendant. Great care was taken to provide a separate cell or compartment for each phase, so that short circuiting between the phases is impossible.

Nineteen similar boards are at present on order for the Dublin Corporation.

Three generator panels, forming a section of a low-tension switchboard, were exhibited. One pole of the machine is provided with a combination switch, which can be operated either as a hand release switch, or by an automatic attachment placed in the panel below. The other pole of the machine is provided with a knife or paralleling switch, a paralleling contact being provided in the panel.

The above panels have been designed to be operated as follows: When it is required to put a machine on to the bus bars, the automatic switch is first closed, the machine is then run up to voltage, the knife or paralleling switch being placed on the paralleling contact. When the machine is at the same voltage as the bars this switch is finally closed. Should there then be any fault in the circuit, the automatic switch at once opens.

With the above arrangement no plugging devices are required, and the possibility of the switchboard attendant making mistakes is reduced to a minimum.

In addition to the well-known "Koker" stoker,

MESSRS. MELDRUM BROTHERS LTD.

exhibited a model of their latest and most improved design of regenerative top-feed "Simplex" destructor furnace in conjunction with a steam generator of the water-tube type. The products of combustion pass from the furnace into the combustion chamber, circulate outside the boiler tubes in passing through the setting usual with this type, through the regenerator tubes to flue and chimney. Cold air, enters on one side of the regenerator, and while being drawn to the Meldrum blowers in the furnace ash-pits, is heated

to about 350 degs. Fahr. This is the initial temperature of the air which effects the combustion of the refuse.

The capacity of this furnace, which has a total effective grate area of 75 sq. ft., is from 40 to 50 tons of refuse per day of twenty four hours, while the boiler evaporation is equal to from 450 to 600 gallons per hour net, allowing 20 lbs. of steam per i.h.p. This is equal to from 225 to 300 i.h.p. per hour.

Fifty different municipalities have destructors of the Meldrum "Simplex" type, for power purposes, on order or in progress, approximately equal to 10,000, i.h.p. per hour.

MESSRS. JOHN J. THORNYCROFT & CO.

had a very interesting exhibit in the shape of an enclosed engine of the double-acting, two-cylinder compound type, with forced lubrication. The h.p. and l.p. pistons drive the cranks, set at 180 degs., of a shaft without a centre bearing. This omission reduces friction, and gives room for a shaft bent from a bar with easy corners and long crank-pins, in which all surface metal is well hammered.

The separate h.p. and l.p. piston valves are driven from opposite ends of a lever rocking between the guides, and actuated directly from the h.p. big-end. Their great lap minimises leakage, while their inertia, balanced as regards foundations, greatly improves the turning moment. The h.p. cylinder and valve chest is separate from the l.p., but connected by a breeches receiver. These, together with a throttle and stop valves, are surrounded by a cylindrical lagging case, on removing the covers of which all covers are exposed. Steam economy is promoted by the flat cylinder ends and ports, by the deep pistons, and by the separator action of the receiver. Close speed regulation is promoted by the small volume of h.p. and l.p. steam chests and by the ease with which the l.p. steam can be throttled. On a sudden fall of load the abnormal rise in speed is hereby so reduced that the normal rim speed of the fly-wheel can be increased proportionately. By a new system the h.p. cut-off can be made late for over-loads without alteration of the valve gear. Ample water relief is provided by three relief valves in each end of each cylinder. Instead of mounting the crank chamber and dynamo on an under-bed, the dynamo bed is bolted to the end of the deep crank chamber. This arrangement gives a good connection under the ring of a multipolar dynamo without side wings, and utilises the full depth of the crank chamber as an oil-settling tank.

We hope to be able in an early issue to publish the drawings and results of tests now being made with the engine.

It has been impossible, within the limits of our space, to refer to more than a certain number of the exhibits, the catalogue of which alone forms a book of no small size, and it must be understood that, although considerations of novelty or importance weighed primarily with us in making a selection, those omitted were not necessarily of inferior interest compared with those described.

All exhibitors succeeded in showing that they are keenly alive to the fact that our local authorities have now thoroughly realised the importance of domestic locomotion, and that they mean to equal if not surpass those abroad, whom they have allowed to obtain so great a start.

The Wolverhampton Exhibition.—III.

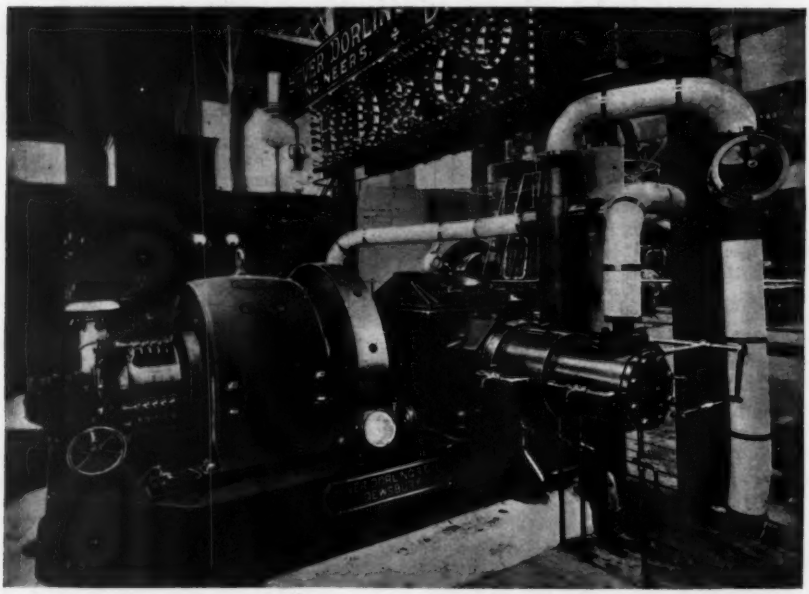
Messrs. Bever, Dorling & Co., Ltd., and The Phœnix Dynamo Co., Ltd.

THE high-speed engine illustrated below represents the latest development of Bever's patent balanced engine, the principal feature of which is that the engine is so arranged that all the working parts are absolutely balanced, both as regards weights and pressures.

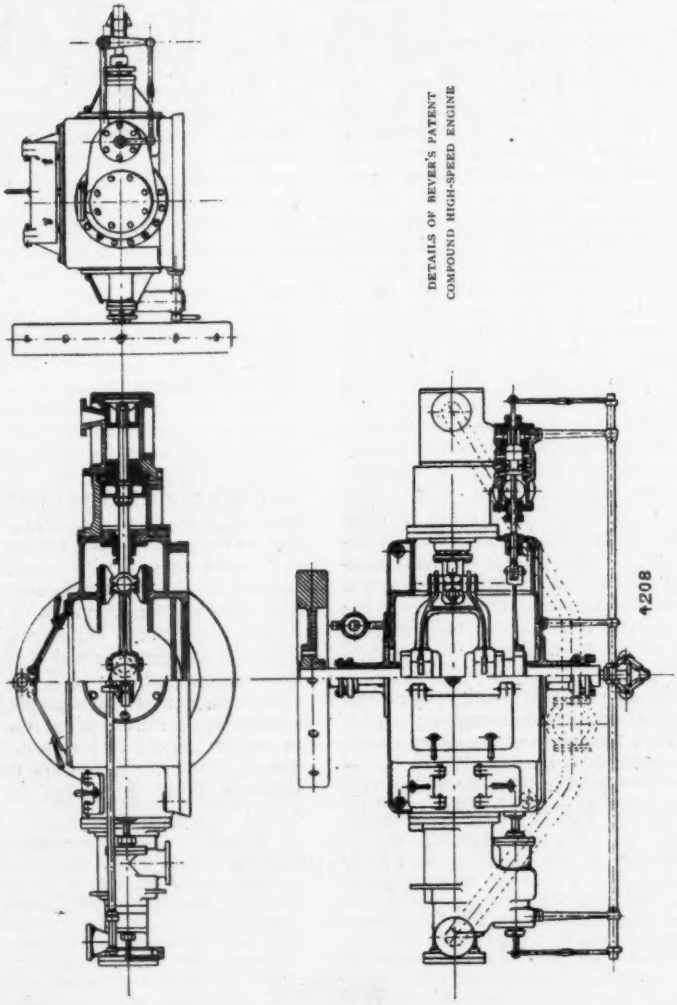
There are, as will be seen from the drawing, two pairs of cylinders, high-pressure and low-pressure, placed tandem on each side of the crank-shaft, the pistons for each pair of cylinders being fixed to piston-rods having cross-heads working in bored guides formed in the centre casing of the engine. These cross-heads are of steel, having shoes of very large area lined with white metal. Stuffing-boxes are provided between the high and low-pressure cylinders and also in the low-pressure cylinder covers, these being fitted with metallic packing.

The cross-heads are connected to the crank-pins on the one side by a straight connecting-rod coupling to the centre one of the three crank-pins, and on the other side by a forked connecting-rod coupling to the two outer crank-pins, which latter are set opposite to the centre pin. By this arrangement the pressures from the two sides are absolutely balanced, that on the shaft bearings being reduced to nil, all the pressure being taken up by the connecting-rods; these and the other reciprocating parts on both sides being of equal weight, are also balanced.

In consequence of this perfect balancing



MESSRS. BEVER, DORLING AND CO.'S HIGH-SPEED ENGINE AT THE WOLVERHAMPTON EXHIBITION DRIVING A 40-K.W. DYNAMO BY THE PHŒNIX DYNAMO CO., LTD.



DETAILS OF BEVER'S PATENT COMPOUND HIGH-SPEED ENGINE

1208

of all pressures and weights, the engine is able to run at a very much higher speed than any other high-speed engines at present on the market, enabling lighter, smaller dynamos to be used; the absence also of vibration at this high speed—viz. 800 revolutions per minute—being most remarkable.

The valves are of the piston type, and are worked by eccentrics fixed on the main shaft. The steam is admitted to the high and low-pressure cylinders in such a way that it expands three times. In the high-pressure cylinder the steam is cut off at about half-stroke on the front side of the high-pressure piston, and after expansion is admitted to the low-pressure back end and is there again cut off at about half-stroke and expanded, then being admitted to the front end of the low-pressure piston after the manner of the old Cornish engine, thus expanding three times with only two pistons.

The back of the high-pressure piston is always in connection with the full-boiler pressure, thus maintaining a constant thrust on the connecting-rods. The engine is controlled by a sensitive high-speed governor connected to two throttle-valves, which are placed in the piston-valve chamber and so arranged that the steam is not throttled until after it has acted on the back of the high-pressure piston, so as to maintain the constant thrust.

All the moving parts of the engine run in a bath of oil, thus ensuring very perfect lubrication, the splash of the oil also feeding the crank-shaft bearings.

To the engine is direct-coupled one 40-kilo-watt 4-pole standard P.D.M. generator, the output of which is 175 ampères at 230 volts when running at a speed of 800 revolutions per minute. This generator has a slotted drum armature "former" wound, with barrel and connections, the armature being parallel-wound for four sets of brushes, the brushes being of the "P.D.M." special radial type, giving long wearing life to each carbon.

This generator has been made by the Phœnix Dynamo Manufacturing Co. of Bradford. The temperature rise of this generator after six hours' run at full load does not exceed 60 degs. Fahr. above the surrounding atmosphere, and it is capable of taking overloads of 25 per cent. for two hours and 50 per cent. for periods of approximately half an hour without injurious heating or sparking. This machine supplies a current to 360 incandescent lamps, four arc lamps, and to an electric-driven three-throw pump.

This pump is of very substantial design, having rams 4 ins. diameter by 7 ins. stroke, and designed to feed against a boiler pressure of 200 lbs. to the sq. in. The connecting-rods have marine type brasses with large wearing surfaces at the crank-pin ends; the forked ends fitting on the rams are provided with pins with taper heads and secured in the connecting-rods by nuts. The rams are constructed with adjustable brasses; the pump barrels are all cast in one piece and provided with three branches for the clack-boxes, which are all of the same design and interchangeable. The suction-pipe for the three pumps is formed in the bed, and is in connection with the flange, as will be seen from the drawing which will be reproduced in the next article.

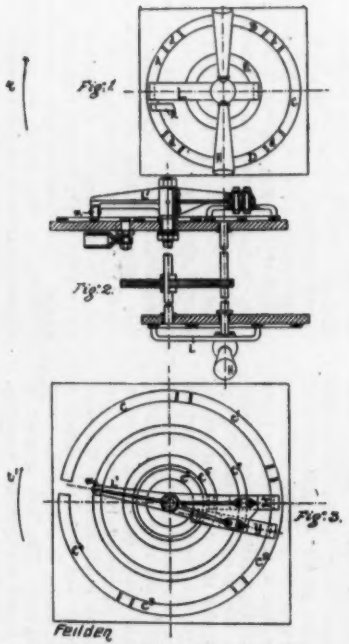
(To be concluded.)

Workshop Practice

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection. See important announcement in advertisement pages.

❀ ❀ ❀

Grouping of Regulating Cells.—With reference to Booster's article on the above subject in the May number of your magazine, it may be of interest to your readers to know that, in 1897, Mr. J. H. Field and myself took out a patent for a switch to accomplish the saving in cable suggested, but we do this by means of two switches operated by one handle only. The accompanying sketch shows how these results are accomplished. I may add that a number of these switches are in use, and in all cases where they are installed a large saving in cable has always resulted. In a recent case that I have in mind, over £200 was saved in cable alone (not including cost of erection). This was in a 3-wire battery system with a 30-way switch at each extremity, the capacity being about 200 amps. The standard switches vary in capacity from 100 to 1,000 amps., while the number of ways vary from 16 to 36 for all sizes. For a 16-way switch only 8 regulating cables are required, while for a 36-way only 12 are necessary. The larger the number of ways, the greater is the economy effected, and there is no doubt that now that 400 to 500-volt batteries are becoming common on 3-wire systems, the employment of such switches would always give economical results. I should like to point out, however, that the idea as suggested by your correspondent, although fundamentally the same as that now made use of in the Heath & Field patent, is shown in a somewhat crude form in the diagram. The idea appears to be to use two separately operated switches. This has three disadvantages:—(1) There are two handles to move instead of one; (2) When the brush controlling the "grouped" cells is moved from one contact to the next, it will cause a comparatively large fluctuation in pressure, which although only lasting until the "pilot" brush has been adjusted to give the required pressure, would be very objectionable in a lighting system; (3) The "grouped" cells have to be partially short-circuited through a resistance attached to the brush, which in itself is a disadvantage, as instance, a 36-way switch, allowing two cells to be cut out at a time by the pilot brush, this would mean partially short circuiting 10 cells, or say 20 volts, and supposing the discharge capacity of the battery was 200 amps., this means (assuming you allow full load current through the resistance while changing over) 4 kilo-watts, and a resistance to absorb this, if only for an instant, would be rather bulky. Now, in the Heath & Field Regulator, all these disadvantages are overcome, while the same saving in cable is effected. The arrangement may be briefly stated as follows:—Two switches are employed, mounted on 11 panels, erected one behind the other as shown in Fig. 2. The front switch is geared to the back one by machine-cut gun-metal spur-wheels, as also shown in Fig. 2. By turning the front switch in one direction, a number of complete revolutions corresponding to the number of segments on the back switch (supposing that before starting all the cells are in circuit), all the regulating cells are cut out. By reversing the direction of rotation and repeating the process, they are all put in again. The disadvantages cited above are overcome in this switch by employing two distinct brushes on the back switch *X* and *Y* (Fig. 3), insulated from each other. The connections of this switch are developed in Figs. 4 and 5, in which the circular switch represents the front switch, which is fitted with a handle, while the straight sliding form



r and r' show the direction of rotation.

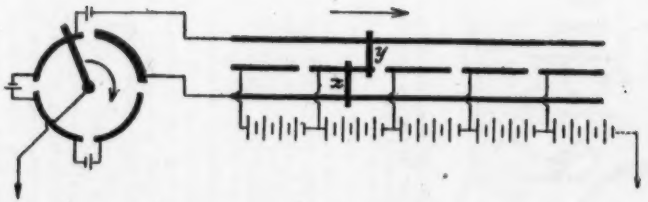


Fig 4.

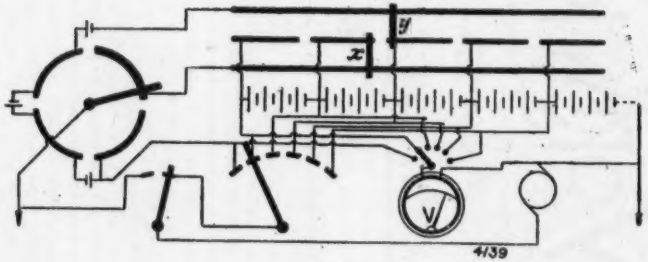


Fig. 5.

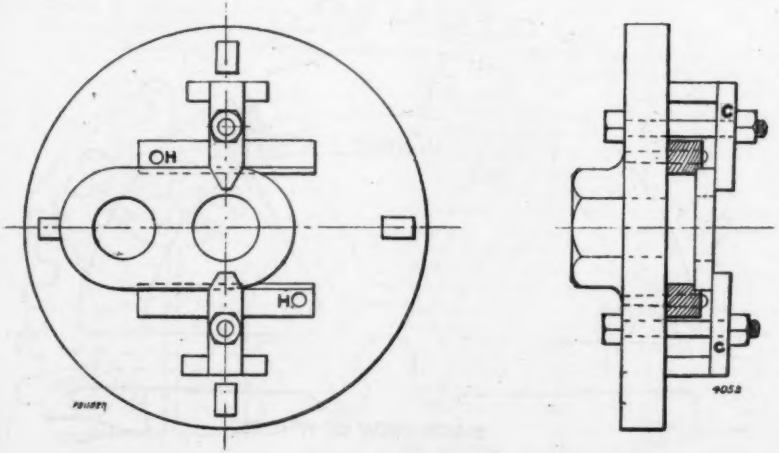
GROUPING OF REGULATING CELLS

of switch shown to the right of this represents the development of the back switch, the brushes X and Y being again marked to correspond. The gearing between these two switches is so arranged that, while the front switch moves from the position shown in Fig. 4 to that shown in Fig. 5, the brushes on the back switch X and Y move from the positions shown in Fig. 4 to that shown in Fig. 5. By tracing the connection on these diagrams, it will at once be seen that before the brush Y leaves its contact (assuming motions are taking place in the direction of the arrow heads), the current is flowing through X only, and before X leaves its contact Y is already on a new contact, and the current is again flowing in Y. It will thus be seen that no current is ever broken at the back switch, which is a most important point, as this is generally out of sight. Further, never more than two cells (assuming this is the number cut out at a time) are partially short-circuited, and this always occurs at the front switch, and only while moving from one contact to the next, and the usual subsidiary arm with resistance is employed. It will be noticed that in Fig. 5 the connections have been developed to show how charging may be accomplished, when it is required to charge at a different pressure to the discharge; that is to say, when it is necessary to keep the battery on the main bus bars while charging is being done. It may here be mentioned, however, that in most modern installations only one switch is employed for charge and discharge, and a booster is connected between the station bus bars and the battery to get the requisite extra pressure for this purpose, and this seems altogether the best arrangement. Of course, in a three-wire system, the centre of the battery would always be kept connected to the middle wire or bus bar.

L. W. HEATH.

A Boring Device.—An arrangement for boring gauge-plates, or similar work, is illustrated in front and side elevations, Figs. 1 and 2. It is composed of two parallel strips of steel, milled or planed to the section as shown at Fig. 2. The advantage claimed for it is, that it saves considerable time in setting, trueing up, and the after process of grinding. The allowance for "buckling" consequent upon the blanking operation, or untrue surface of the metal, can be reduced to 50 per cent. to 60 per cent., whether the finishing be done by the lathe or more modern grinding machine. Two holes H, H' (Fig. 1), about $\frac{5}{16}$ or $\frac{3}{8}$ diameter, are drilled equidistant from the centre of and through the lathe face-plate, these coincide in diameter with the ones drilled at exact distances from edge of steel strips. Two pins, slightly taper, hold them in position; but allowing them freedom to fall on the edges of the link or plate to be bored, which is then held by the clamps C, C'. The rebated portion of the strips is about $\frac{1}{4}$-in. by $\frac{1}{4}$-in., which gives sufficient bearing; and the length is made convenient to width of work and radius from pivots H, H'.

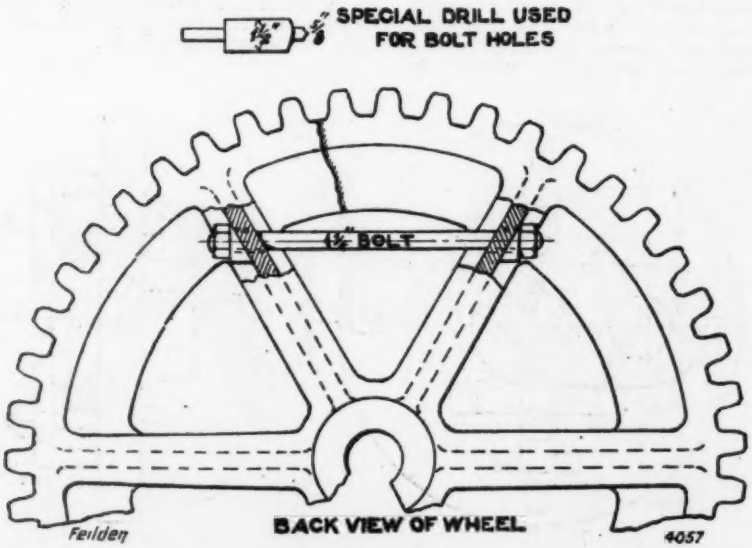
G. WEEKS.



A BORING DEVICE.

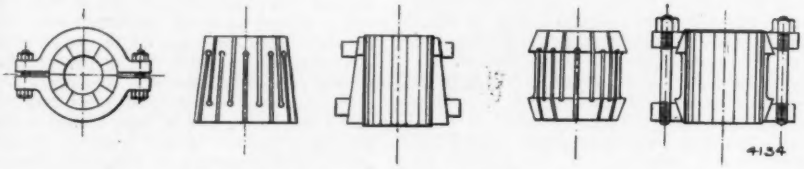
A Good Mill-gearing Repair.—A short time ago a cast-iron machine-moulded bevel-wheel, as illustrated, and used for driving a portion of a cotton mill, cracked across the rim at the part shown. It was decided to put in a pair of new steel wheels; and as serious inconvenience would result by stopping the shafting while new wheels were cast, an attempt was made to repair the broken wheel in the manner shown. This proved entirely successful: the wheel to all appearance seemed to run like a sound wheel, and as the speed of the wheel was quite up to the average, something like 49·48 ft. per second, or say 3,000 ft. per minute, at the pitch line, a description may be of service to users of toothed gearing. The wheel was 4 ft. 6 ins. diameter, 10 ins. wide on tooth, and 3¼ ins. pitch, transmitting 120 h.p. at 210 revolutions per minute; and it was thought that bolting a plate behind the rim would weaken it, as the bolts would necessarily have to be from the root of the teeth to the back of the rim, it was decided to drill the arms carrying the broken part of the rim, and bolt together with a 1¼-in. forged bolt. The drilling of these two holes was done by a special drill, shaped as shown, with a small nose ⅞ in. diameter, this small part being easily started at the required position by chipping: on the small drill taking hold, the larger part (1¼in. diameter) would follow easily. Wrought-iron washers were put under the nuts to form a level bearing; and when the bolt was fixed the ends were riveted slightly over the nuts to prevent "slacking back" when the vibration commenced. When the wheel was run it sounded clear and true, it being impossible to distinguish any sign of fracture. JAMES R. KELLY.

Clamps for Small Commutators. — In clamping commutators during manufacture the type of clamp shown at Fig. 1 is generally used. I have, however, found in practice that the best results are not always obtained, as the commutator will very often be found elliptical. This would mean that the mica between the segments is not uniformly gripped; and after the commutator is turned and the clamps removed, undue stress is set up, the commutator is not symmetrical, and is therefore mechanically and electrically weak. The difficulty, no doubt, is due to judging the right amount that the clamps should be smaller than the loosely set-up commutator, but it will also depend on the stiffness and the degree to which the clamps are screwed up. In Fig. 2 is shown a clamp which I made and used some time ago; and not having seen anything better nor equal in my workshop experience or the articles I have read, I thought a few remarks might be



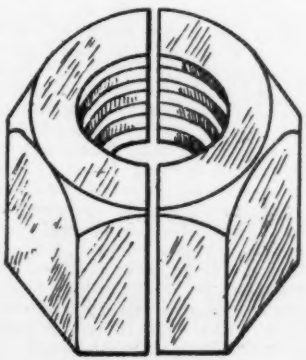
A MILL-GEARING REPAIR.

useful to others. Fig. 2 consists of a parallel bored tube, tapered outside and split, and two steel rings, as shown. By this means we get a very flexible bush, which will allow for slight variations in diameter of commutator. If difference is rather great it may be packed with cardboard or sheet tin, which should be cut so as not to overlap. This taper bush may be made of steel, brass, or even wood, and will last a long time if the rings are pressed or driven on with care. These clamps are not so dangerous in use, and are more convenient in clamping to face plate or gripping in jaw chuck. This, however, will depend on the appliances and practice of manufacture and the design of commutator. The clamp (Fig. 3) would, I think, give more satisfaction than Fig. 2, as the steel rings could be much easier forced on and removed. The number of screws should vary according to diameter of commutator. (*Award.*) H. HELLFRITSCH.



CLAMPS FOR SMALL COMMUTATORS.

Split Nuts as Clamps.—This simple and handy device is extremely useful to both fitters and machinists alike, yet how many possess a set? By their use a fitter can hold a threaded stud or bolt in the vice without fear of damaging the thread, which would otherwise be a rather difficult thing to accomplish. The halves of the nut are put on the stud or bolt, and the vice closed up against the sides of the split nut, when the saw groove cut through will allow the halves of the nut to grip the stud firmly. For the lathe hand they can be used to slip on the threaded end of bolts, pillars, etc.; a carrier then being fixed on the nut and screwed up tight, the whole lot will drive without fear of damaging the thread, instead of having to hunt round the shop looking for sheet copper, etc., as is usually the case. They are also handy for shapers as well, for nipping screwed work in the vice to be operated upon. It is simply a nut cut across the centre with a hack-saw. J. GREEN.



SPLIT NUTS AS CLAMPS.

White Metal Bearings.—In the early days of the large quick-revolution electric-light engine, several firms who had previously devoted the whole of their attention to the manufacture of so-called "slow-speed," tendered and received contracts for large steam-engines of the former type. Among the difficulties experienced by some of these firms, not the least was that of keeping the crank-shaft and "bottom-end" bearings cool, when the engine was running on load, as the engineers in charge found to their cost. White metal bearings being the most frequently employed, such as have given trouble through overheating, have been effectually dealt with in the following manner. Instance a crank-shaft bearing fitted with white-metal which, whilst running, is gradually rising in temperature although the bearing is flooded with oil. The first change in the white-metal is the formation of bright spots at those points on its surface where the crank-shaft bears the hardest. Next, the skin of the metal commences to "drag" at these points, and if the temperature still rises, will drag to such an extent as to completely fill up the oil grooves in the bearings. Finally, the metal will become fused to a greater depth,

and will then run out. The method recommended is to allow the bearing, while well lubricated, to run until heated up to the point at which the bright spots referred to above are formed, which will take place at a temperature upwards of 180 degs. Fahr., according to the composition of the alloy. The bearing should then be opened out and the surface where the bright spots have formed carefully removed with a scraper. This process should be repeated until the whole bearing presents a close-grained, brightly-burnished surface resembling silver, which will work with a remarkably low co-efficient of friction—this in spite of the fact that two manufacturers of anti-friction alloys state that the alloys manufactured by them run best with a dull surface. The following are two cases where the above method has been successfully employed :—(1) A large vertical quick-revolution engine indicating about 1,500 h.p. gave a lot of trouble with its main bearings, in spite of their being fitted with forced lubrication. The engine as originally designed was to have been supplied with auxiliary spring-supported bearings; but these were not fitted, consequently the pressure per square inch on the main bearing surface was very excessive. Owing to the trouble mentioned above, the engine was never able to remain on the town circuit for more than an hour or two at a time. After several weeks, during which every effort was made to get the engine into running order, without success, the plan recommended was tried, and the bearings have given no trouble since. (2) The thrust-block bearings of an American mail-boat had constantly given trouble through overheating. It was the practice to keep a stream of water playing upon them practically from port to port, and at the end of each trip the shoes, which were faced with white metal, were taken out in a terrible condition. Prior to one trip the shoes, after being re-metalled, were scraped up and bedded to the collars with the greatest possible accuracy, and after the ship sailed the hose-pipe was—with the consent of the chief engineer—kept from playing on the bearings, which were flooded with a good oil. The temperature, however, began slowly to rise, and the chief fixed upon a limit temperature, and gave orders that when this was reached the water service was to be immediately turned on. Readings were frequently taken with a thermometer, and the temperature gradually rose to within 3 degs. of the limit temperature agreed upon, and after remaining at about that point for twenty-two hours, began slowly to go down. When the shoes were taken out in port they showed a beautiful silver-like surface, and were put back without being touched. This vessel then ran on four consecutive trips without the thrust-block giving the slightest trouble.

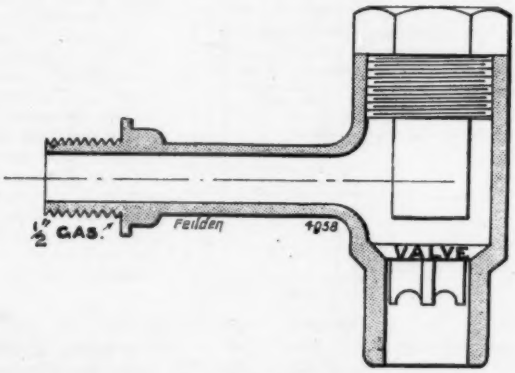
C. L. B.

Releasing Oil Engine Pistons.—The following is a method successfully adopted on several occasions to release oil engine pistons, which have become fast through the use of bad oil, etc. This type of engine is often located in out-of-the-way places, where special tackle is not always available. The first part of the operation is to get a short piece of timber, and place between connecting-rod and outside of cylinder, so that if the rod is forced upwards the strain will come on the timber, and not on the edge of the cylinder, as the strain falling on the latter would probably break it. The rod should then be disconnected from the crank end, and a short sling of 1-in. rope looped behind bolt at other end of rod lying in cylinder. Now place other loop of sling over throw of crank, and turn driving wheel slowly, then shorten sling by knots when piston is moved. Clean piston and rings thoroughly with benzoline, allow time to evaporate, then lubricate freely with good cylinder oil.

HORACE COULTARD.

An Auxiliary Valve.—While sinking the shafts of a Warwickshire colliery we encountered a large volume of water—about 2,200 gallons per minute. In dealing with this quantity four pumps were at work, having a pumping capacity of 1,700 gallons per minute, with sixty strokes. In order to overcome the excess of water—500 gallons—we decided to increase the speed of the pumps to seventy strokes per minute: but with this alteration a fresh trouble was set up: the motion of the pumps became so rough that it was not advisable to be near them, owing to the bursting of clack-box, splitting of barrel, and broken air-vessel. Suddenly one of the pumps began to work with a very steady motion, and upon examination we found a joint partially blown out at the bottom of the working barrel. The joint was repaired, with the result that the knocking and jumping was renewed. We further examined the pump, and slackened the nuts of the same joint until the pump got a little air. The knocking ceased at once, but we could not allow this joint to continue blowing, as the sinkers were unable to work under it. After some thinking I invented a small valve (Fig. 1), which opened by the atmospheric pressure when the vacuum was formed, and allowed a little air to enter the

pump, then passing into the air-vessel, and closing when the pump delivered. This enabled us to run the pump at ninety strokes a minute without difficulty, and in less than a month from supplying each pump with a similar valve we sank through 12 yards in this heavy feeder, and tubbed it off. Prior to this we had not gone 1 yard in five weeks. The valves were screwed into the working barrel near the bottom of the stroke, and the air-vessels, which had been previously wet



AN AUXILIARY VALVE.

all over, were now only partially so; thus indicating the quantity of air contained therein, and demonstrating the efficiency of the valve as applied to the pumps, the latter with the now safe, accelerated speed giving 30 per cent. better results.

J. M. WRIGHT.

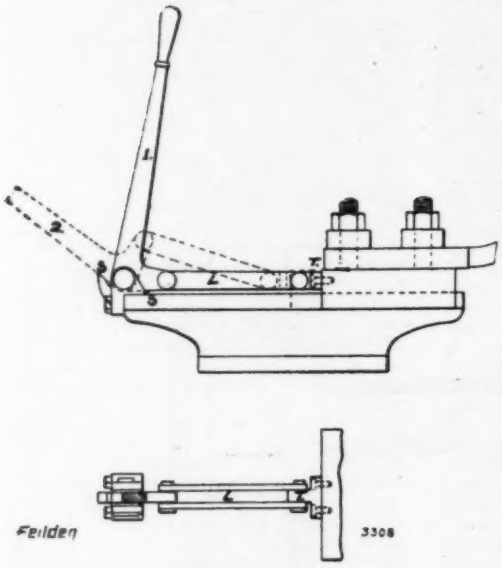
Inside Screw Gauge.—Every engineer knows the difficulty of hardening a screw gauge to keep its form without warping and altering size, etc. The illustration is of one that is not only a serviceable gauge, but also a fairly cheap one. *A* is a mild steel or cast-iron

INSIDE SCREW GAUGE.

disc, knurled on the outside for a good grip, and internally bored taper. *B* is of tool steel, first turned taper on the outside to fit *A* when pressed flush, and with a slight recess, as shown, turned in the centre of diameter. When this is fitted in *A* the whole is chucked, and the desired pitch and diameter machined to suit. After finishing, and when ready for hardening, press out *B*, and harden by the usual method adopted for this class of work. Possibly the gauge may be distorted in this operation, but on pressing back to its original position it will be invariably found to have regained its correct form.

TOOLMAKER.

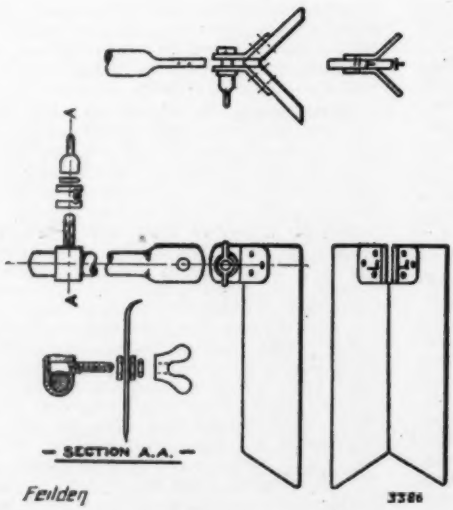
Screw Cutting.—At Figs. 1 and 2 is shown an arrangement for facilitating the operation of screw cutting in an ordinary lathe. The ordinary method of withdrawing the tool for the return of the slide is far from being satisfactory, the operator having to watch the marks on the end of the cross slide screw and allow for the depth of the cut each time a cut is made, and as the time for doing this is short, the operator is never quite certain whether the cut is too heavy or not heavy enough before the tool is again cutting. By the method shown the cross slide is fed-in during the return of the tool, which gives the operator time to be quite certain of the amount of cut he is giving the tool, the lever moving the tool exactly equal distances each time. The arrangement is fixed by setting the compound rest for cross traverse, then taking out the traversing screw and fixing on the rest the fulcrum as shown, together with the bell



SCREW CUTTING.

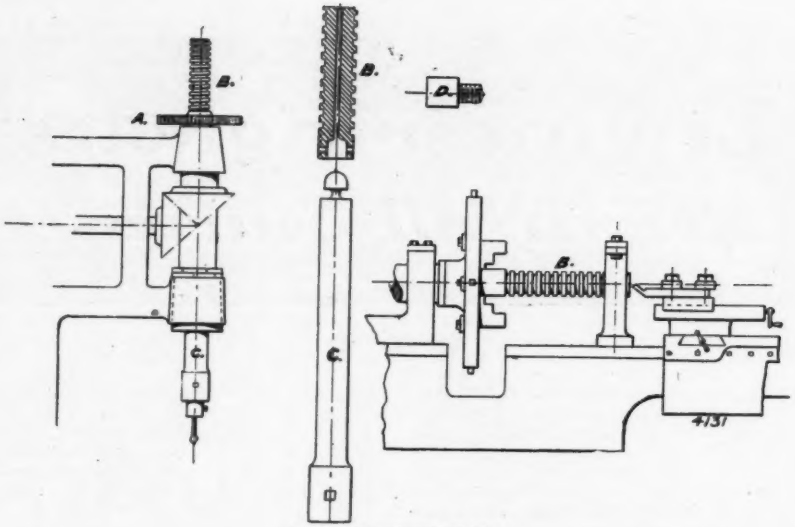
crank lever. Now fasten the tee piece *T* to the rest, and connect this to the lever by the links *L*. To operate, secure the tool as ordinarily, and put the lever in position 1, that is, resting on the stop S_1. The links now being on the dead centres, will transmit the thrust of the tool direct to the fulcrum without any tendency to move. Set the depth of the cut by the cross slide as usual, and take a cut up the screw blank. When the tool has travelled as far as required, the operator draws out the tool by pulling the lever over to position 2, that is, against the stop S_2. The motion of the saddle is now reversed, and during its return the cross slide is fed in the amount of the next cut. When the starting place is again reached the saddle is restarted in the original direction, and the tool pushed into place by putting the lever into position 1: the cycle of operations being repeated until the screw is finished.

S. W. C.



SCRIBING BLOCK.

A Useful Scribing Block. — The appended sketches illustrate a useful scribing block, which is a development of the ordinary "angle-iron" one used by borers, and over which it has these advantages:— The pillar can be set at any angle even to vertically downward, the scriber can be slid for its entire length through the cross-head, and this latter revolves on the pillar. This universal adjustment makes it exceedingly convenient on certain jobs on the boring machine, and also on planers, etc., and it is an all-round indispensable tool for general work. The slight amount of extra trouble in making, which can be almost eliminated by a little thought, is amply repaid by its utility. The lugs *L L* (bent cold) should first be drilled for the rivets, and also with a small hole to allow the temporary liner *T*, placed between them, to be just lightly riveted in. This liner must have the same thickness as the flat end of the pillar. When these two lugs, thus correctly distanced, are accurately fitted and riveted to the base (the rivet holes in the base being marked out through those already



A DRILLING MACHINE REPAIR

drilled in the lugs), the liner is removed and the hole left rimered or filed out to fit the bolt. The inside faces of the lugs and the flat end of the pillar should be filed rough to perfect the grip. In the cross-head *A* the small hole must be drilled first, and then the larger one with a twist drill, as it encroaches on the diameter of the smaller one. This type of cross-head requires no lathe work, and is simpler to make than the ordinary double affair, which, of course, can be used if preferred. E. H. H.

A Drilling Machine Repair.—The splined feed-screw *B* (Figs. 1 and 2) of a drilling machine had the bottom part twisted off, and the thing to be considered was the best way to deal with it in order that the machine should be stopped the shortest possible time. This was accomplished by taking out the screw, and gripping the top end in a four-jaw chuck, supporting the other end in a stay, as shown at Fig. 3, and facing off the ragged end. The faced end was then bored, and cut with a fine thread 16 per inch; a tightly fitting plug *D* was then turned and screwed in. This was further secured by a taper pin driven through, the whole being again placed in the lathe, and bored to suit the top of spindle *C*, as shown. J. B.

AS a further inducement to our Artizan readers, and an additional subject of interest, we have decided to assign one page per month to questions bearing on the Workshop and Practice therein.

A query, if deemed suitable, will be inserted and paid for, together with what is considered by the Editor to be the best reply to the same. The decision of the Editor to be final.

The questions and replies should be written on one side of the paper only and should arrive not later than the *second* week in the month for insertion in the following month's issue.

Engineering Notes From all Sources

THE paper presented by Mr. E. T. Ruthven-Murray on this subject, before the meeting of the Municipal Electrical Association, was of an interesting character, especially in view of the scheme for electric lighting and traction at Willesden, where Mr. Murray is putting in double-current generators.

Double-Current Generators.

Alternating current is generated either by simple alternators or by double-current dynamos, the latter being machines designed to supply alternating or continuous current from one armature. It is eminently suited to combined lighting and tramway systems, as the tramways can be supplied directly from the continuous-current side of the machine, while the lighting can be provided for on the alternating-current side through transformers and rotary converters. Further, the possibility of being able to dispense with a balancer, by connecting the neutral wire of a three-wire system to the centre of the star of a star-grouped transformer feeding a rotary converter, or fed from a double-current generator, is a further advantage. In construction such a machine is identical with a rotary converter, the armature windings being connected to both commutator and slip rings. Separate excitation is adopted when it is required to supply both lighting and traction circuits, although the shunt and compound field methods may be resorted to.

It may be employed with advantage where otherwise separate continuous and alternating machines would be put down, and by its employment economy in both capital expenditure and running expenses will result.

A number of large double-current generators are now in use in America for both lighting and tramway service, in several cases the frequency of the alternating current being 60 per second. It is within the writer's knowledge that there will shortly be at least four electricity supply works in this country using double-current machines. The largest will be of 1,200-kilowatt capacity. Three generators of this size—32-pole machines running at 94 revolutions per minute—are being put down to operate the Mersey Railway. The frequency will be 25 per second, and the continuous-current voltage 650.

Mr. Ruthven-Murray is putting down two 300-kilowatt double-current generators at the present time, some particulars of which may be of interest. Each dynamo will deliver continuous current from the commutator and three-phase alternating current from the slip rings, and is capable of giving:—

1. The full output as a continuous-current dynamo with either shunt or compound excitation.

2. The full output as a three-phase alternator.

3. Any proportion of continuous or alternating current up to the full output of the machine.

Each machine will carry 20 per cent. overload for two hours, 40 per cent. overload for short periods, and, while delivering full load on either alternating or continuous-current side, will be capable, at the same time, of delivering 50 per cent. of full load on the other side for one hour without injurious heating. From no-load to 20 per cent. overload collection will be sparkless, with no alteration to the lead of the brushes. The working pressure on the continuous-current side will vary between 480 and 560 volts as shunt, and 500 to 550 volts as compound, the voltage on the alternating-current side being 0·61 per cent. that of the continuous. The dynamos will be 12-pole, running at 250 revolutions per minute, and the frequency will be 25 per second.

The Misuse of Coal.

Following on Professor Perry's communication in *Nature* on this subject is a rejoinder in a later number of that publication in which it is pointed out that the ability of being able to fix the energy of the sun by growing wood is generally overlooked. Helmholtz compared the number of thermal units received by an acre of land in Germany during a year, with the number of thermal units produced by burning the vegetable matter elaborated during a year. His calculation was that only the $\frac{1}{1177}$ part of the sun's heat was thus rendered available.

On this basis it is possible roughly to calculate the maximum thermal efficiency, as firewood, of the wattle or eucalyptus vegetation on the coast of Australia or South Africa, the maximum South African yield being five times the European yield of spruce. But since the average weight of eucalypt wood is three times that of spruce, the heating power produced on an acre of eucalypts must be set at about 15 times that produced on an acre of northern and mid-European forest. Thus on the basis of Helmholtz's calculation a eucalypt plantation can, with the most favourable circumstances, in South Africa or on tropical mountains, store up, say, $\frac{15}{1177} = 1$ per cent. of the solar energy received on the unit of area.

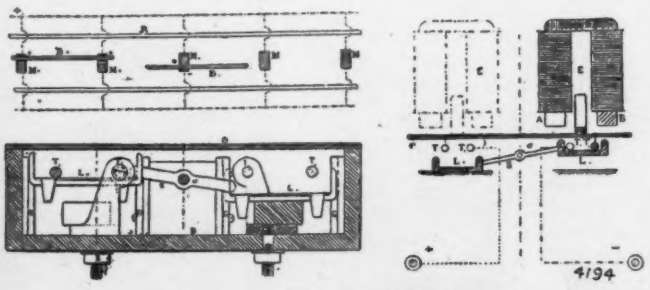
Eucalypts planted on tropical mountains will produce wood fuel at the rate of 20 tons per acre per year in perpetuity. The eucalypt plantation reproduces itself when cut, without further expense, and its dry timber, heavier than coal (which, as met with commercially, weighs 50 lbs. to 52 lbs. the cub. ft.) has an equal or a higher thermal power, bulk for bulk, than coal. No doubt when the coal supply is exhausted, selection and experiment will produce a forest vegetation that will produce more than double this quantity per acre per year. A powerful sun, a heavy rainfall, and a very rapid forced growth would be the essentials of such a production of wood fuel.

Looking at a rainfall map of the world, one sees that these conditions are fulfilled over about 8,000 million acres of its surface, one-half of which under forest might thus yield the equivalent of 161,000 million tons of coal yearly, which is more than 288 times the world's present consumption of coal, assuming that coal and eucalypt timber are of approximately equal heating power. On the basis of the actual forest yields of to-day we have half this, or 80,500 million tons. In Germany one-fourth of the total area is under forest, and this is held on the highest authority to be the suitable proportion for a thickly-peopled civilised country such as Germany. Taking the German standard of one-fourth forest, on the basis of to-day's maximum yields the writer states that we should obtain a yearly output of 40,250 million tons. And if to convert the maximum forest yield to an average forest yield we again divide by two, we obtain 20,175 million tons. *It is a little more than thirty times the world's present consumption of coal.*

Thus, proceeds the writer, we see that the yield of firewood from the world's tropical and extra-tropical forests, whenever they are fully stocked and scientifically worked, will yield the equivalent of from 30 times to 122 times the present consumption of coal, or even up to 243 times the present consumption of coal, if we succeed by cultivation in doubling present timber-yield figures.

Cruvellier Surface-Contact Electric Railway System.

A new surface-contact electric railway system has, according to the *Electrical World and Engineer*, recently been installed on a car track at Neuilly, France, near Paris, one of the main features of which is that the main track does not form a part of the conducting system, the car-current connection being with plus and minus surface-contacts.



NEW SURFACE-CONTACT SYSTEM

Referring to the Fig., *B*, *B* are the car-contact makers, and *M* the surface-contacts, which become alternately plus and minus. Normally the surface-contacts are neutral, but become negative

when under the forward contact maker, and positive when under the rear contact maker.

Fig. 3 shows the manner in which this is done. The top *C* of the surface-contact is connected with either of two horizontal bars T_1 and T''_1. Two other bars, T_2 and T''_2, are connected, one with the positive feeder and the other with the negative feeder. By means of *L*, *L*, which are connected to the lever *S*, the top *C* may be connected with the negative or positive feeder connection as indicated in the cut. The lever *S* is pivoted at *A*, to prevent the two parts *L*, *L* from being raised at the same time, the effect of which would be to cause a short circuit. A series of electro-magnets *E* mounted in the front part of the carriage determines the attraction of minus *L*, and a second series of electro-magnets *E'*, mounted in the rear of the car, acts on *L*. These two sets of electro-magnets, as may be seen in Fig. 1, are not in line with each other with respect to the car longitudinally. Thus when the forward part of the car is over a contact, the part *L* plus is raised and connects with T'_1, the cover *C* then becoming negative. As the car proceeds, the part *L* minus falls when the polar projections *A B* have passed over the cover, and then the electro-magnets *E'* come into play, which causes the raising of *L* plus, rendering the corresponding contact-cover positive.

The two series of electro-magnets *E*, *E'* may be installed either on the same car or on different cars. Fig. 2 shows the actual contact-boxes. Owing to the small extent of contact at the conducting bars when a circuit is made, there is apt to be a slight soldering to the bar. To provide for this case the movable part of the contact arrangement is in two parts, one consisting of a movable non-magnetic portion with lugs, as shown in Fig. 2, on which the contact is made. Should this stick, it will be left behind when the lower part drops away, until near the end of the motion of the latter, when a projection thereupon serves to release it. The car-contact consists of a metal ribbon passing over two pulleys, the lower surface of the ribbon rubbing on the tops of the contact-boxes.

Mechanical Stokers for Locomotives.

In a paper recently presented before the American Institution of Mechanical Engineers a description was given of a mechanical stoker devised by Mr. John W. Kincaid. It is a mechanical and not an automatic machine, for while it might be quite possible to devise the latter, it has been proved that it would not be as effective as though controlled by a skilled fireman. Its advantages may be summed up as follows: It enables the steam pressure to be kept at or near the popping-point, thus securing increased work from the locomotive; it obviates the necessity of constantly opening the fire-door and admitting large quantities of cold air into the fire-box; it gives even distribution of coal over the whole grate; it ensures constant and regular firing, which has been estimated to represent a saving of 10 to 20 per cent. in fuel, and reduces the black smoke nuisance some 75 per cent.

The stoker is attached to the opening of the fire-door, which it replaces, and consists of a hopper, ram, ram-body, ram-cylinder, steam-chest, door-frame, conveyer-cylinder and its valve-chest. The conveying screws are actuated by the piston in the conveyer-cylinder, which travels up and down and operates the screws by ratchets. A globe-valve admits steam to the valve-chest of the ram, and the motion of this ram is controlled by a valve which gives three different strokes in regular order. The first stroke throws the coal to the front of the fire-box, the second to the middle, and the third just pushes it over the deflector-plate, making the distribution practically perfect.

The coal can be fed into the hopper by gravity—by means of a standard tank modified for this purpose—and the fireman will then only have to run the stoker. Should it be necessary for any reason during a run to start firing by hand, it is a simple matter to disconnect the stoker and swing it to one side, or unhook it entirely, without any delay being caused. It will handle any kind of fuel, from anthracite to lignite, and ranging from lump coal to slack. Should a lump too large for the ram get caught, it would lift the auxiliary fire-door, which has a lip for this purpose.

The machine can be speeded as high as 28 strokes per minute, throwing a 10-lb. charge at each stroke, which would give 16,800 lbs. per hour, more than would ever be likely to be called for in practice.

Electrolysis of Pipes.

The question between electric railway companies and those who are interested in underground piping systems, as to what is the best means of protecting the latter from damage from earth currents, and who is to pay for this protection, is one of great moment, and is dealt with in a recent number of the *Electrical Review* of New York. When the return-current trouble first arose, the problem was temporarily solved by connecting the return system of the electric railway tightly on to

the piping system where this showed rapid corrosion, thus enabling the current to leave the piping through metallic contact, which eliminated electrolytic action at those points. The current, however, still remained in the pipes, and traversed their length, and small portions of it were diverted through strata of more or less conducting powers, and particularly around joints where the electrical conductivity was bad, resulting in a general corrosion of the pipes. The only permanent and effective means of stopping the damage arising from earth currents is to keep the current out of the piping systems. This can be partially accomplished by reinforcing the return-feeder system, but as long as the pipe system presents any conductivity whatever, it cannot be completely effected by this means. The remedy is to break up the electric continuity of the piping system by insulating joints, 20 or 30 of which, properly distributed, would reduce the current in the piping system more than an almost infinite amount of copper laid in multiple with it. It seems only reasonable that steps to protect the pipes from damage should be taken by both parties ; if the electric railway companies protect and reinforce their ground return, those who are interested in underground piping must instal their systems in such a way as not to suffer damage from earth currents.

With the increasing use of concrete as a structural material, the demand for a definite knowledge of its physical characteristics becomes more and more urgent. Unfortunately, concrete varies radically in quality according to its composition and preparation, and, of course, what should be its constants suffer like fluctuation. There is one constant, however—the coefficient of expansion—which probably varies but slightly. The object of a paper recently read by Prof. W. D. Pence is to elucidate this point ; for which purposes experiments were made at the School of Engineering, Purdue University, upon a make of concrete representing the best practice in the combined concrete-steel type of arch work. The proportions of the mixture were 1 : 2 : 4 ; and the scheme of the experiments comprised the heating of a bar of concrete of known length through a determined range of temperature, and the measurement of its alteration of length in the circumstances. Simple as was the programme, it took much time and trouble to carry out. The heating was done by a steam jacket. The concrete bars were cylinders 36 ins. long and 4 ins. diameter. The final results showed that for gravel concrete, the co-efficient of linear expansion is 0·00000054 per deg. Fahr. ; and for limestone concrete, 0·00000055 per deg. Fahr. This value is conveniently remembered as being "five zeros fifty-five." Prof. Pence remarks that the usual assumption of equality and expansion of steel and concrete is erroneous by 15 per cent. Still this discrepancy is not likely to be of very serious moment in working.

The Coefficient of Expansion of Concrete.

The Electrician gives the following particulars and results of the experiments conducted by Mr. Trotter, and which were referred to by him at the meeting of the Municipal Electrical Association :—First, two 18-in. lengths of 1¼-in. pipe were laid parallel to one another about 6 ins. apart, and a current of 1 amp. at 83 from the Deptford mains was passed between them. The pressure was 100 volts, the dampness of the earth being adjusted to maintain 1 amp. A distinct and sharply-defined incrustation on the lead, evidently due to electrolysis, was observable in six weeks. It was confined on each pipe to about 45 sq. ins. This effect was then compared with that of still lower current densities by burying a series of plates in the same way, the first plate having a surface of ¼ sq. in. exposed (the remainder of the plate being painted), the second a larger surface, and so on up to 9 sq. ins., the density of current sent through the series being $\frac{1}{160}$ amp., so that the current density at the surface of the first plate was $\frac{1}{40}$ amp. per sq. in., the same as on the pipes, and on the last plate $\frac{1}{1440}$ of an amp. per sq. in. The incrustation on the first plate was comparatively thick, and even on the largest plate of 9 sq. ins. surface showed slight but unmistakeable signs of corrosion. The outermost faces of the series of plates showed only very slight traces of corrosion, which latter effect was observed after four weeks. Mr. Trotter regards the results of his experiments as a proof that alternating currents will electrolyse lead pipes at current-densities lower than 1 ampere per square inch.

Experiments on Alternating-Current Electrolysis.

Many kinds of alloys have been used in the construction of surface-condensers, but the whole cause of the extensive pitting trouble experienced with these, says an article in *Power*, can be summed up in the one word "Electrolysis." Condenser tubes are generally made of copper, or an alloy containing a large proportion of copper, while

Failure of Condenser Tubes.

the tube-plates and shell are of iron; the addition then of the circulating water, containing more or less salt, completes the electrical couple, and electrolysis takes place. Wherever the current leaves the tubes pitting occurs, caused by the formation of oxides and other salts of copper. In cities where the electric railway, with the use of the ground return, is employed the trouble is accentuated, the condensers and circulating pumps being affected to a greater extent than is usually thought possible. Sewage in the condensing water also intensifies the action. It has been proposed to insulate the condenser, but nothing would be gained by this, as the main electrolytic action is not due to outside influences but is in the condenser. German silver and the kindred alloys of copper and nickel are claimed to be the best materials for the tubes, although an ideal condenser should be one with a copper shell, copper tube-sheets and copper tubes, with copper gaskets between shell and tube-sheets and copper packing in the glands. All joints would then be metal to metal, and there would be no breaks in the circuit; for it must be remembered that the current will jump every break, and electrolysis takes place wherever the current passes out of a metallic conductor.

New Railway from Nottingham to Retford.

The Bill for the Nottingham and Retford Railway is passing through Parliament as an unopposed Bill, and was read a third time in April last. The proposed new railway is 30 miles in length, and holds the record for mileage in Private Bills of this description in the present session. The line makes a direct connection between the above-mentioned towns, thereby greatly improving the existing intercommunication, and forms junctions and connecting lines with the Great Northern, Great Central, Midland, and Lancashire, Derbyshire & East Coast Railways. The line commences at Nottingham by junctions with both the Great Northern and Great Central Railways, and continues in a more or less direct line northwards, tunnelling under Dorket Head, Eakring Brail Wood, and Wellow Wood, and, crossing the Midland Company's line near Farnsfield Station, and the Lancashire, Derbyshire & East Coast Railway Company's near the village of Boughton, finally forming a junction with the Great Central Railway immediately to the east of Retford Station.

The line is being promoted by the large landowners through whose estates it passes, with the intention of developing the very important coalfield which is believed to exist under this portion of the county. The engineers for the construction of the line are Messrs. Edward Parry and F. W. Bidder, MM.Inst.C.E.

Lattice Girders in Buildings.

Although not frequently employed in this country in building construction, lattice girders might advantageously be adopted in cases where the use of supporting columns constitutes an undesirable obstruction, says *The Builder*. The new building for the New York Stock Exchange exemplifies the judicious employment of trusses forming the main support for the ceiling and four stories above the board room, an apartment measuring nearly 110 ft. wide by 140 ft. long by 52 ft. high. There are four main trusses, with a combined weight of 419 tons, and each is about 15 ft. deep, 4 ft. wide, and 115 ft. long. They are arranged in pairs, the two inner trusses being connected by six lattice girders which support the upper floors and the end walls of a light shaft, while the two outer trusses carry the ends of plate girders extending across to the outer self-supporting walls of the building. The trusses are carried on eight interior steel columns, braced together in pairs, each column measuring 3 ft. 7 in. by 4 ft. in cross section. This mode of construction involves the application of steel on a scale not often contemplated in Great Britain, and the essential result is a structure of magnificent proportions entirely unobstructed by pillars.

The Capetown Exhibition.

Particulars have reached us concerning a scheme for holding a British and Colonial Exhibition at Capetown, for a period of four months, from November, 1903, to February, 1904. The directorate have been fortunate enough to secure the patronage of Lord Milner, Sir J. Gordon Sprigg, The Capetown Chamber of Commerce, while a cordial reception has been accorded to the scheme, coming, as it does, at an opportune moment, and with a "Militantly British" programme, by other chambers and merchants of our South African Colonies.

All the necessary funds, we understand, have been guaranteed, and the site and buildings arranged for.

Further information may be obtained from Mr. A. P. Baker, the General Manager, who is at present in England, staying at Seymour Grove, Manchester.

REVIEWS.

Primary Batteries. Their Theory, Construction, and Use. By W. R. Cooper, M.A., B.Sc., Associate Member of the Institution of Civil Engineers, Associate of the Institute of Chemistry, etc. (London: *The Electrician* Printing and Publishing Co., Ltd.)

The primary battery has been the subject of much investigation since it was first discovered, at first largely because it opened up an entirely new field of knowledge—that of the relations between chemical and electrical energy; and more recently because of its high efficiency when compared with that obtained in the production of electrical energy from the combustion of coal, with steam generation as an intermediate step. But in spite of the amount of work that has been published on the subject, we do not find generally among practical electricians that knowledge of the theory of the primary battery and of its limitations in practice that we might reasonably expect in view of its importance. At the present time such knowledge is even more important than formerly; for we have now electro-chemical industries based on practically the same theoretical considerations as those which arise in the study of the primary battery. The present volume is therefore especially welcome, and Mr. Cooper is to be congratulated on his successful treatment of a somewhat difficult subject. The scattered literature on the subject is here brought together in a condensed and readable form, and the author has added the results of his own investigations on the different types of battery, thus giving a means of comparison of the capabilities of these types which was not hitherto available.

After a brief historical sketch of the investigations on primary batteries, Mr. Cooper devotes a chapter to consideration of the simple voltaic element, and another to local action and polarisation. In the first of these two chapters we note with satisfaction that the author emphasises the distinction between "e.m.f." and "potential difference," and points out that a clearer conception of the facts may be gained by the correct use of these terms. In the chapter on polarisation a very full account is given of the different methods adopted for depolarisation, the chemical action in each case being explained. Two chapters are devoted to the theory of the voltaic cell. The first of these deals more with the question of the seat of the e.m.f., introducing therefore the different theories of contact-electricity, while in the following chapter the electrolyte itself is considered, and the theories of electrolytic conductivity discussed. These two chapters, which may readily be mastered by any intelligent reader, show that the author has not only a thorough knowledge of the subject on which he writes, but that he has the power of imparting that knowledge to others. His descriptions here and throughout the book are clear and concise. The subsequent chapters are devoted to descriptions of the different types of cell in use, and their capabilities are discussed. Many curves made from the results of the author's own investigations appear throughout the book, and give a ready means of comparison of one type with another. In this connection the tables on pp. 230 and 231, giving tests of different types of dry cells, and comparisons of wet with dry cells, are especially useful and instructive. The last chapter in the book is one of the best, and should be read by all would-be inventors who desire to revolutionise the commercial generation of electrical energy by substituting a carbon-consuming primary battery for the present steam and electric engines. It is devoted wholly to the consideration of the possibilities in this direction, and the author points out one or two important items which are sometimes forgotten. We have not seen elsewhere so full and critical a discussion on this attractive but unpromising subject, and we cordially recommend our readers to give it their earnest attention. But the whole book ought to be carefully read, for it is an excellent treatise on an important subject by an able writer, who has spared no pains to make his work accurate and attractive, and has in both respects achieved complete success.

Electric Power Transmission. A Practical Treatise for Practical Men. By Louis Bell, Ph.D., Member of the American Institute of Electrical Engineers. 3rd Edition (1901), revised and enlarged. 632 pp., with 21 plates and 285 diagrams. (New York: *Electrical World and Engineer*, Incorporated)

The success which has attended the publication of Dr. Louis Bell's work on "Electric Power Transmission" is shown by the fact that a third edition has been called for within five years of its first appearance. During these years, although there have been no startling changes in the general art of power transmission, a great advance has been made in the perfecting of methods, in knowledge of the possibilities of high-tension transmission, and in the elimination of objectionable features in alternate current working. These advances, it must be said, are due to the American electricians, for in this country we are only now on the threshold of experience of long-distance transmission. For this reason, however, the present work will be all the more useful to British engineers; and we have no hesitation in saying that all practical men interested in the subject, or called upon to deal with it, will derive great benefit from an intelligent reading of these pages. In some respects American practice is different from what we are likely to see in this country; for it is very doubtful if the authorities here will ever allow transmission by overhead wires, where we are dealing with such exceedingly high voltages as are now used in America. The use of underground cables, of course, introduces some difficulties —*e.g.* resonance effects—not so pronounced in the case of overhead wires; but the discussion of these points by Dr. Bell, although finally applied particularly to overhead lines, is in the first place quite general.

The book is too long for us to give a detailed discussion or description here, but it will be sufficient to say that the author first gives an account of the elementary principles involved and of the general conditions of power transmission, and then proceeds to discuss the transmission itself, first by continuous, and then by alternating

currents. The general chapters on the properties of, and transmission by alternating currents are especially good. Practical men are too often frightened away from attempting to grasp the theory of alternating currents by the amount of mathematical investigation involved. It is quite true that for a complete grasp of details a considerable knowledge of mathematical analysis is required, but the general principles may in reality be understood with a very moderate knowledge of mathematics; and the author has been very successful in his non-academic method of explanation of these principles. Later chapters are devoted to synchronous and induction motors, current reorganisers, engines and boilers, water-wheels, and hydraulic development — this last contains much useful information on practical points and some valuable hints on the considerations to be kept in mind in dealing with water-power schemes. After dealing with the organisation of a power station, and discussing the line and its construction, the author devotes a chapter to centres of distribution, in which he deals at length with the methods of distributing electric energy after it has been received from the transmission line. The chapter following is on the commercial problem, and although it only occupies seventeen pages, it contains a very useful and very readable account of what is undoubtedly a very important factor in the question of power transmission. The chapter on the measurement of electric energy contains nothing very novel, and some of the instruments described may not be recognised by British engineers, as their use seems to be confined to the other side of the Atlantic; but the general description is not affected by this, and affords useful instruction for practical engineers. The final chapter shows the present state of high-voltage transmission, and gives a table of the American schemes in which a pressure of or above 10,000 volts is used. It may be remarked that this list contains the names of no less than seventy schemes in the United States, twelve in Canada, and eight in Mexico. The author's description of the occasional discharges from high-tension lines, and Plate xviii., giving a photograph of a huge arc over 10 ft. in height, surrounding all the wires at the top of a pole 40 ft. high, do not increase our desire to see this system in general use in this country, at least with pressures of 40,000 volts, as in this particular case. The discussion of the difficulties to be dealt with when using such high pressures is of the greatest interest. Throughout the book the author has maintained a high level of merit, both in the literary matter and in the wise selection he has made in dealing with so vast a subject, any one branch of which is in itself sufficient to occupy a volume as large as this. We feel quite certain that the labour expended by the author in revising his work, and in bringing it up to date in every respect, will earn its reward in an increased popularity for the book.

RECENT CATALOGUES.

Pooley's Patent Weighing Apparatus. Henry Pooley & Son, Ltd., original makers of the Platform Weighing Machine. Works: Albion Foundry, Kidsgrove, Staffs; Albion Works, Glasgow; and Albion Scale Works, Birmingham.

The new and enlarged edition of the catalogue of Messrs. Pooley's, whose patented platform weighing apparatus was adopted by the first railway, and still holds its own as the standard weighing apparatus for railways at the beginning of the twentieth century, is full of useful instruction, illustrated by clear cuts, regarding the best suited weighing apparatus, not only for railways but also for mines, manufactures, and general commerce, for which the firm, since the appearance of the previous issue of the catalogue, has received numerous additional prize medals and other distinctions, to be added to the numerous awards of a similar nature granted to Messrs. Pooley since the firm was established nearly a century ago. Of the many interesting devices described the self-acting and self-recording apparatus is of special interest, and a very praiseworthy feature is the recognition given throughout to the metric system, which, sooner or later, will conquer even the time-honoured prejudices of our British captains of industry. The attention of our readers is directed also to the ingenious patented devices introduced by the makers to protect their customers against errors in readings of weight, and to prevent fraud by manipulating the exposed screw balance.

Brush Electric Traction Catalogue. The Brush Electrical Engineering Company, Ltd., 49, Queen Victoria Street, London, E.C. Works: Loughborough, Leicestershire.

The catalogue of this great firm, which is second to none of the many large companies that have sprung into life since the use of electrical energy for practical purposes became an established fact, covers the whole range of apparatus required for or connected with electric traction plant and rolling stock. Engines, dynamos, alternators, motors, controllers, trucks, and car bodies are all represented among the output of the works of this company at Loughborough, which was one of the first in England to recognise the signs of the times and to put a check to the conquest of British territory by American firms. The catalogue is neat in appearance, well printed and illustrated, and contains a lucid, though rather concise, description of the various objects represented in the engravings.

The Newton Electrical Works, Ltd., Taunton, England.

The catalogue of the above-named firm of manufacturers gives a concise description, together with illustrations, of various types of dynamos, motors, transformers, switch-board and switches, and other electrical apparatus, which are among the best known manufactures of their kind, and are in demand not only in the United Kingdom, but have secured to the Newton Works contracts of the Russian, Japanese, Canadian, and Australian Governments, and thus obtained an international reputation.